AMERICAN CHEMICAL INDUSTRY

THE CHEMICAL COMPANIES

Edited by
WILLIAMS HAYNES

VOLUME VI

D. VAN NOSTRAND COMPANY, INC.
TORONTO NEW YORK LONDON

NEW YORK
D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3
TORONTO
D. Van Nostrand Company (Canada), Ltd., 228 Bloor Street, Toronto 8
LONDON
Macmillan & Company, Ltd., St. Martin's Street, London, W.C. 2

Published simultaneously in Canada by
D. VAN NOSTRAND COMPANY (Canada) LTD.

PRINTED IN THE UNITED STATES OF AMERICA

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INTRODUCTION

THE HISTORY of the American chemical industry is a multicolored skein with many knots and loops and loose ends. To unravel it into a thread of straight narrative, maintaining chronological order and making clear the interwoven technical and economic, the political and social factors that have influenced our chemical development, it has been necessary to divide the record into time periods—the various volumes of this set--when generally speaking the same or at least closely related conditions constituted the background of the industry's activities. Within this chronological framework, it has been further necessary to trace the growth of the industry by making various groups of chemicals (the chapters) the basis of detailed development. It has sometimes been logical to gather these groups together upon a strictly chemical basis, as the acids, the alkalies, the coal-tar chemicals. In other cases it has been expedient to use a classification based upon use, as in the case of fertilizers and insecticides, synthetic fibers and plastics, and the various coatings. Since most chemical enterprises manufacture many products sold in diverse fields, such a treatment gives only a scattered, incomplete idea of the history of an individual company.

As from a general history of the United States one learns little of the history of the various states of the Union, so in the preceding volumes one learns but little of the growth of the various chemical-manufacturing corporations, their contributions to our national chemical development, or their position in the whole industrial picture. Accordingly, this volume is an obligatory appendix to the historical record of the industry.

Recognizing that 219 histories, written by the companies themselves, would naturally vary greatly in length, style, and content, the Advisory Committee instructed that all be edited, not to uniformity, but to strictly factual, almost encyclopedic form. In following these instructions, some of the life, the glamor, if you will, has been boiled out of these accounts, but the essential facts have been scrupulously preserved and in the main they have gained in precision and clarity. This condensation has been essential to keep the company histories within the scope of a single volume comparable in size to the others in the set.

In styling the manuscripts for publication it has been necessary to make certain concessions to that uniformity which is a prerequisite of good editorial practice. For example, the companies appear in the following pages in strict alphabetical order and each company's history opens with the firm name. In order to take fullest advantage of this device to make this volume self-indexing for ready reference, the word "The"—which is frequently an integral part of the corporate title, as The Dow Chemical Company and The Tilden Company—has been uniformly dropped from that opening sentence. Accordingly, there can be no doubt that Dow will be found under "D" between Dorr and Drackett and Tilden under "T" between Thompson-Hayward and Titanium Division, National Lead Company. With this added emphasis upon the alphabetical arrangement, the official corporate title appears in the running folios at the top of the pages.

Proper identification of the trade names of chemicals and compounds registered in the U. S. Patent Office is important because the courts have repeatedly ruled

that by common usage such a registered trade name can become a generic noun over which the original owner has no exclusive rights and which anyone may use. Valuable assets in these trade names, often created at great pains and expense, can thus be sacrificed. The words "aspirin" and "cellophane" are familiar examples of this principle of the law. Not only in this volume, but throughout this work, I have therefore repeatedly mentioned that these coined words are the trade names of such-and-such a company and they have invariably been printed with a capital first letter. The common names of chemicals and compounds, as well as their commercial synonyms and trade abbreviations or nicknames, appear with a small letter. The capital first letter is reserved as the distinguishing mark of a registered trade name and this use is to be recognized as identifying these proprietary words. With this explanation of the style uniformly adopted, it is not necessary to enclose trade names in quotation marks or to set them in full capitals, unnecessary precautions that by overstressing these coined names are flavored with a faint taint of over-zealous "public relations."

The "company historians" deserve thanks not only for their original labors, but also for the cordially cooperative spirit in which they have executed their thankless, anonymous task. I admire, too, and very much appreciate, the almost unfailing, generous tolerance with which they have accepted the strictures of the editorial blue pencil.

WILLIAMS HAYNES

Stonecrop Farm
Stonington, Connecticut
February ninth, 1948

ABBOTT LABORATORIES had its inception in the desire of the founder, Dr. Wallace Calvin Abbott, to obtain dependable alkaloidal and active-principle granules. Dr. Abbott received his M.D. from the University of Michigan in 1885 and in 1886 entered practice in Ravenswood, a suburb of Chicago. At that time unstandardized fluidextracts and tinctures were in general use, and the indefinite and changeable results from such preparations led him to study medication based upon administration of the pure alkaloids or active principles in definite dosage in the form of granules. Dr. Abbott prepared these granules in his own home. In 1888 he began to supply them to other physicians. His first advertisement appeared in the *Medical World* in June 1891. It cost 25¢ and brought in $8 worth of orders. In a short time the growing business was moved to a near-by house, then it overflowed into two adjoining houses, and in 1901 into a three-story brick building.

The business was incorporated in 1900 as the Abbott Alkaloidal Co. The manufacture of products other than granules, such as Saline Laxative and Calcidin (a new type of iodine preparation), was begun about this time, and between 1900 and 1914, the extraction of many alkaloids and glucosides formerly purchased. A veterinary department was organized in 1909 the nucleus of a chemical research staff was formed, and the manufacture of phenolsulfonates, the Company's first organic synthetic work, undertaken.

Young men destined to lead the Company were added to the pay roll. In 1904, two future presidents, Dr. Alfred S. Burdick and S. DeWitt Clough, joined the organization, the former as editor, the latter as advertising manager of the medical journal, *The Alkaloidal Clinic*. Dr. Burdick was graduated from Rush Medical College, Chicago, in 1891. He became vice-president in 1916 and president following the death of Dr. Abbott, July 4, 1921. He continued as president until his death on Feb. 11, 1933, when Clough succeeded him and served as president for 13 years. After Clough's elevation to the chairmanship in 1946, Rolly M. Cain was named president, an office he held for 11 months until his death, Feb. 21, 1947. He had previously served as executive vice-president and assistant general manager for 13 years. In 1909 he and his associates organized Swan-Myers Co. of Indianapolis, and in 1913 he became its president, a position he held until that company was merged with Abbott in 1930. Cain was also president of Abbott Laboratories International Co. and Abbott Laboratories Export Corp., 1943-46.

At the beginning of World War I, the firm name was changed to Abbott Laboratories. In 1916, after Dr. H. D. Dakin, the English chemist cooperating with Dr. Alexis Carrel in France, had published his paper on the remarkable germicidal properties of the chloramines, Abbott began the manufacture of Chlorazene, and later dichloramine-T, Chlorcosane, and Halazone. The latter was extensively used during World War II for water purification in forward areas.

During World War I, at the request of the Government, Abbott undertook the manufacture of many synthetics formerly imported from Germany: barbital and procaine, both urgently needed by the Army; later, cinchophen, neocinchophen, acriflavine, neutral acriflavine, and anesthesin. These drugs were prepared under license from the Government and later from the Chemical Foundation. As a result of its war activity, Abbott received a distinguished service citation from the Government.

In 1922 Abbott acquired the Dermatological Research Laboratories (known as

D.R.L.) in Philadelphia, set up in 1912 by a group of research chemists and physicians as a nonprofit undertaking to study the cause of psoriasis. D.R.L. continued with work in chemotherapy, studying particularly mercury and arsenic compounds. In the spring of 1915, D.R.L. scientists (Drs. Jay Frank Schamberg, John A. Kolmer, and George W. Raiziss) were the first in the United States to prepare arsphenamine, which was supplied to the Government at far below the German price. It was the nation-wide discussion of the Salvarsan situation which brought to a head the question of utilizing enemy patents. Neoarsphenamine was also quickly developed by D.R.L. In the early days a batch was made in six-gallon porcelain containers. Now 500-gallon glass-lined tanks are used. Profits from the sale of arsphenamine and neoarsphenamine were used by D.R.L. to establish an endowed research laboratory. The commercial patents and properties were sold to Abbott in 1922. Dr. Raiziss remained as director of D.R.L. Division until his death, July 16, 1945. Metaphen, an organic mercury germicide, and Bismarsen, a derivative of arsphenamine containing bismuth, were two other products developed under Dr. Raiziss after D.R.L. became part of Abbott. The D.R.L. property in Philadelphia was presented to the University of Pennsylvania in 1945 as a memorial to Dr. Raiziss, and manufacturing and research activities were moved to North Chicago.

In 1928 Abbott acquired John T. Milliken & Co., St. Louis, which made it possible to supply a more complete line of general pharmaceuticals. In 1930 Swan-Myers Co., Indianapolis, was merged with Abbott. The biological and ampule preparations and other products of this concern further rounded out the Abbott line. Milliken and Swan-Myers brought to Abbott an additional number of experienced executives, technicians, and research workers, e.g., Cain, fourth president, and Edgar B. Carter and Charles S. Downs, directors.

Abbott's first research was directed toward local anesthetics, and one of its earliest developments (1920) was Butyn Sulfate for topical anesthesia. Continued work led to Butesin, butyl *p*-aminobenzoate, and Butesin Picrate, both local anesthetics. Simultaneously, intensive research in hypnotics was undertaken, based upon experience gained in the manufacture of barbital. The first product to show clinical advantages was Neonal, introduced in 1923. Shortly, new alcohols containing four to six carbon atoms became available and were used by a group under Dr. Ernest H. Volwiler to produce branched-chain barbiturates. In 1929 this work materialized in the commercial introduction of Nembutal [sodium ethyl- (l-methylbutyl)-barbiturate]. The shortness of action of Nembutal suggested that it might be suitable as an intravenous anesthetic. Clinical experience demonstrated that it was a step in the right direction and Abbott developed many analogous substances, which led to the discovery that introduction of sulfur into the barbiturate molecule shortened the duration of action and conferred other properties desirable in a general anesthetic. The compound selected as most useful from the several hundred prepared was sodium ethyl-(l-methylbutyl)-thiobarbiturate, now known as Pentothal Sodium.

The Abbott research group early in 1945 made available pure crystalline *d*-tubocurarine, one of the active constituents of the South American Indian arrow poison, which has the peculiar and valuable property of relaxing skeletal and abdominal muscles.

One of the principal, relatively unsolved problems of therapeutics is that of nervous diseases. Phenobarbital and a few of its analogs have been found to be of some benefit in certain types of epilepsy. The difficulty with research in this field has been the pharmacologist's inability to duplicate this condition in experimental animals. The Abbott pharmacologic group has studied chemical convulsant agents,

as well as electrical methods, for producing irregularities in the patterns of brain waves, resulting in the introduction of Tridione (3,5,5-trimethyloxazolidine-2, 4-dione) which offers promise in the field of petit mal, a form of epilepsy common in children and young adults. Considered a pain-relieving drug in the experimental stage, the anti-epileptic properties of Tridione were discovered accidentally. Certain amounts of the antispasmodic now known as Amethone normally produced fatal convulsions in mice, but when given with Tridione no convulsions or fatalities occurred. Abbott entered the synthetic antihistaminic field in 1947 with Thenylene Hydrochloride, a drug for oral use in the treatment of allergies and certain types of asthma.

Early in 1929, the Abbott research staff quickly made use of the Schmidt-Nielson finding that halibut liver oil was much richer in vitamins A and D than cod liver oil, by erecting an extraction plant adjacent to the wharves of the halibut fishing fleet. This use of fish liver oils other than cod liver oil permitted high dosage in a small capsule. Subsequently other fish liver oils, such as those of the tuna, shark, etc., were studied and used. Abbott has remained active in the field of vitamins and has made available such pure materials as calcium pantothenate, vitamin K, etc. It has specialized also in developing pharmaceutical preparations of other pure vitamins. In 1936 Abbott succeeded in packaging A, B_1, C, D, and G in a single small capsule known as Vita-Kaps, and multiple vitamins were subsequently introduced in more potent and complete form in Dayamin Capsules. Two Abbott vitamin specialties are designed especially for children: Vi-Daylin, a clear, homogenized mixture of six vitamins, with a pleasant citrus flavor; and Cecon, a stable solution of vitamin C, which can be administered in drop doses. Until his recent retirement, Carl Nielsen was director of nutritional research and directly responsible for the development of many of these products.

Abbott entered the sulfa field early and has been active in the production of sulfanilamide, sulfapyridine, and the subsequently developed heterocyclic analogs.

During World War II, Abbott began the manufacture of quinacrine hydrochloride (Atabrine), which it supplied in large quantities, as well as Pentothal Sodium, Halazone, and acriflavine, to the Armed Forces. It also produced large amounts of desiccated blood plasma.

During recent years a notable proportion of Abbott Laboratories research has been directed towards antibiotics. Penicillin was produced during the early part of the war by the pan fermentation process. Later, the plant was completely redesigned to employ the latest type of deep-tank fermentation. Abbott now has two large new buildings for the fermentation and extraction of antibiotics. An outstanding Abbott specialty, the so-called Romansky Formula—penicillin in a semisolid mixture of peanut oil and beeswax—when injected intramuscularly permits the maintenance of penicillin blood levels for approximately 24 hours. Another advance was made in 1945 with the production of streptomycin, whose manufacture is similar to that of penicillin, except that it is removed by absorption, instead of solvent extraction, and eventually winds up as streptomycin sulfate, a soluble powder. Continual change in the manufacturing process is the rule for both penicillin and streptomycin. Intensive research goes on with other antibiotics in the hope of discovering some that are superior or supplementary to those already in use. Supervising the work on antibiotics, as well as other research, is Dr. Robert DeWolf Coghill (Ph.D., Yale 1924). Through his work as chief of the Fermentation Division, Northern Regional Research Laboratory, U. S. Department of Agriculture, he did much to make commercial production of penicillin feasible. He came to Abbott in 1945 as associate director, and a year later became director of research.

Growth of the Company necessitated a move to larger quarters after World

War I. Edward H. Ravenscroft, chief engineer and director of production (now chairman emeritus of the board), and Ferdinand H. Young, now vice-president in charge of production, recommended a 26-acre tract in North Chicago, Ill., which was purchased and where construction started in 1920. The move from the Chicago plant and office was completed in 1925. Erection of new buildings had been practically continuous since then. Notable among them is the research building, completed for the 50th anniversary ceremonies in 1938, and more than doubled in size in 1947. In the pharmacology building, likewise doubled in size in the postwar building program, the extensive biological research and control activities are housed. Near by is the development laboratory where chemical engineers translate or make small lots of drugs not yet in commercial production.

The management of Abbott Laboratories is entirely in the hands of full-time employees. Top direction rests with the board of directors, now composed of 17 members, which meets daily for lunch. Eight officers make up the executive committee. E. H. Ravenscroft, chairman of the board since 1933 and emeritus chairman since 1946, came to Abbott in 1908 and was general superintendent in charge of production, plant layout, and pricing; he designed many of the Company buildings at North Chicago. Clough, present chairman and past president, started working in the Abbott advertising department in 1903. Raymond E. Horn, president, general manager, and director of sales, came to the Company in 1922 with D.R.L. He was made general sales manager in 1933, vice-president of sales in 1937, and president, Apr. 3, 1947. Dr. Ernest H. Volwiler, executive vice-president and assistant general manager since 1946, joined Abbott in 1918, the year he received his Ph.D. from the University of Illinois. Chief chemist since 1920, he became director of research in 1930 and vice-president in charge of research and development in 1933.

Financial direction is under James F. Stiles, Jr., who started with Abbott in 1913 and was elected treasurer and director in 1930, vice-president in 1933. Ferdinand Young began in the Drug Extraction Department in 1910 and advanced to executive positions in chemical manufacturing until in 1933 he was elected a director, becoming vice-president in charge of production in 1944. The award of the Army-Navy "E" with four stars may rightly be considered a tribute to his leadership. Legal affairs are handled by Alfred W. Bays, who has served as general counsel since 1919. He was named a director in 1924, secretary in 1933, and vice-chairman of the board in 1947. Vice-president in charge of public relations and advertising since 1946 is Charles S. Downs, who came to Abbott in 1930 with Swan-Myers, he was named advertising manager in 1935, and a director in 1944. Vice-president in charge of purchases is Edmund L. Drach, who started in the Pharmaceutical Department, 1904-14.

Medical director is Dr. Joseph F. Biehn, who has been with Abbott since 1909. He received his M.D. from Northwestern University Medical School, where he later taught bacteriology. He developed and directed the extensive program of clinical research carried out in cooperation with hospitals, clinics, medical schools and private physicians. Edward A. Ravenscroft, director of engineering since 1944, was first employed as an engineer in 1925, becoming department manager four years later.

Floyd K. Thayer, director of chemical sales since 1925, came to Abbott in 1920 as a research chemist. Claude A. Thornburg, assistant treasurer and director of auditing, started in 1924 as bookkeeper; was elected a director in 1937. Hugh D. Robinson, plant superintendent since 1939 and director since 1946, began working as a chemical operator in 1921. Director and manager of the control laboratories is Elmer B. Vliet, who joined Abbott in 1919 as a research chemist. George R. Cain,

a director and secretary of the executive committee since Apr. 3, 1947, started in the Sales Department, 1940.

Employees are covered by voluntary group health insurance and a liberal retirement plan.

The business was an individual proprietorship until 1900, when it was incorporated in Illinois for $50,000, the principal stockholder being Dr. Abbott. As the need arose for additional funds, Dr. Abbott sold stock to employees, friends, and business associates. The stock was closely held until Mar. 1929, when it was first offered to the public. Additional stock was sold (by issuing rights) at various times, and stock dividends and split-ups were given to the stockholders. The present outstanding stock consists of 1,869,907 shares of no-par value common stock.

Abbott products are sold through the regular drug channels, with 37 sales districts and 18 branches in the United States. Hundreds of medical service representatives call upon physicians, dentists, pharmacists, hospital personnel, and veterinarians to keep them informed of new and standard products. Steady increases in sales even during the depression testify to the effectiveness of the Sales Department. Foreign sales are conducted through two subsidiaries, Abbott Laboratories International Co. for Latin America, and Abbott Laboratories Export Corp. for Europe, Asia, and Africa, with main offices in Chicago. Affiliated companies have offices, warehouses, and small manufacturing plants in a number of foreign countries. Abbott pharmaceuticals were shipped abroad to 117 geographical divisions in 1947.

The Abbott Laboratories Science Club was the first research group in the pharmaceutical industry to be granted affiliation with the Society of Sigma Xi (May 1945). Graduate fellowships of $5,000 each have been given to 10 universities to support research in medicinal products for a five-year period. The universities are given the sole right to publish, patent, license, or otherwise dispose of the results of the research, and are not restricted regarding the type of problems selected.

AIR REDUCTION COMPANY, INC., was founded on the commercial development and application of two gases, oxygen and acetylene. In 1895 a French chemist, Henri Le Châtelier, discovered the oxyacetylene flame, a jet of oxygen directed into a jet of burning acetylene, producing a flame temperature of around 6,300° F., hotter than any other man-made flame. The same year a method of producing acetylene commercially was introduced. There remained the need for a low-cost method of producing oxygen. This proved to be the air-liquefaction process which a German scientist, Carl von Linde, was the first to accomplish commercially by 1901, when he produced liquid oxygen.

But to use these gases commercially in welding and cutting, new apparatus had to be invented. A practical welding torch was perfected by two Frenchmen, Fouché and Picard, in 1901. Three years later, the first torch used in this country was sent by Fouché to Eugene Bournonville, cofounder of Davis-Bournonville, subsequently an Air Reduction subsidiary. In 1906 the first job welding shop in the United States was opened in Pittsburgh. The first public oxyacetylene demonstration was given, June 13, 1907, at the Williamsburgh Bridge in N. Y. City, where a cut 5 ft. long was made in an iron stringer. That same year Bournonville demonstrated at the Brooklyn Navy Yard how portholes could be cut by one man in 3-in. armor plate in less than 30 minutes, which had previously taken a foreman and five men 10-14 days. The New York Central was the first railroad to use the oxyacetylene torch in the demolition of the old Grand Central Station, at an estimated 1/20th the cost of other wrecking methods.

At this time two of the later founders of Air Reduction bought the rights to a secret compound for brazing cast iron. These two men, Percy A. Rockefeller, nephew of John D., and Robert C. Pruyn, noted Albany banker, began operating in 1905 as the American Ferrofix Brazing Co.

By 1907 industry had developed a pressing need for the oxyacetylene process, but still the stumbling block was lack of low-cost oxygen. Much of the limited amount available was being produced by chemical processes or electrolytically from water at high cost. Late this year the first plant to produce oxygen from the atmosphere began operation. Pruyn, convinced of a great future in oxyacetylene welding, interested Rockefeller and they got in touch with a young sales engineer working for Bethlehem Steel Corp., Herman Van Fleet, who in 1908 began working for one of their enterprises, the American Oxygen Co., then producing oxygen from potassium chlorate and manganese dioxide. Van Fleet was soon convinced the brazing process was a failure and turned all his attention to finding a commercially satisfactory way of making oxygen at a small plant at Camden, N. J. Several chemical methods were tried, of which a barium oxide process proved the most economical, but even by this method any large-scale use of oxygen would have been prohibitive. About 1911 Van Fleet discontinued operations at Camden and began experiments on a method of producing oxygen from the air. An abandoned livery stable was rented in West Philadelphia for $35 a month and by 1914 the unit was producing about 10,000 cu. ft. of oxygen per day.

At this time L'Air Liquide, desiring to have its liquefaction process for production of oxygen developed in America, sent W. T. P. Hollingsworth to this country. Becoming acquainted with the progress of American Oxygen Co., he opened negotiations with Rockefeller and Pruyn, resulting in an interchange of patent rights and the formation of Air Reduction Co., Inc., which was incorporated Nov. 26, 1915. When a name was being considered, Van Fleet recalled that in his native Colorado a number of companies treating ores to obtain gold were known as "reduction" companies. Because of the similarity between the reduction of ore and the reduction of air by liquefaction, the name "Air Reduction" was chosen as fitting. The first officers were Walter W. Birge, president; Van Fleet, vice-president; Philip L. Dodge, treasurer; J. D. Tansill, secretary.

From the start, Air Reduction's products were in great demand, particularly by railroad and shipbuilding companies. Feb. 11, 1916, ground was broken in Philadelphia for the Company's first oxygen plant. Before operations had begun, its entire output had been contracted for. So great was the demand that plants were acquired in Brooklyn, Chicago, Pittsburgh, Defiance, O., and St. Louis. Oxygen plants were built in 1917 in Jersey City, Detroit, Cleveland, Emeryville, Calif., and Oklahoma City. Equally essential to oxygen in the oxyacetylene process are acetylene and apparatus. Consequently, in 1917 the Company built acetylene plants at Gloucester, N. J., and Kansas City, Kans., and a plant for manufacturing welding and cutting apparatus in Jersey City. In the same year, through purchase of the Searchlight Co., the Company acquired acetylene plants at Chicago, Boston, Minneapolis, and other locations, including one for the manufacture of acetylene cylinders (Chicago). Air Reduction Sales Co. was formed in 1917 to operate the company plants and market its products.

New and spectacular uses of the oxyacetylene process followed the ent[illegible] United States into World War I. One of Air Reduction's important [illegible] tions was liquefaction equipment for producing nitrogen at the Mus[illegible] Nitrate Plant. Van Fleet, who left the Company temporarily to join th[illegible] trate Corp., was in charge of the design of specifications in the plant [illegible] 30

nitrogen units produced 15,000,000 cu. ft. nitrogen per day. During World War II these same plants were converted from nitrogen to oxygen production.

From the beginning, the importance of research was recognized by Air Reduction management. This led to a chemical research laboratory in Jersey City, in 1917, to further the use of oxygen, nitrogen, and acetylene, to develop by-products, to solve plant problems, and to develop new and improved products and processes. The laboratory aided the Government during World War I by developing methods for the production of ammonia for high explosives. The research plant was making ammonia from sodium cyanide produced from atmospheric nitrogen piped from the oxygen plant as a by-product. The plant also developed methods of producing helium from natural gas. In 1920 the laboratory moved to Elizabethport, N. J. By this time it was recognized that the purity of oxygen had much to do with its effectiveness in cutting metals. Furthermore, the rare gases were attracting increased attention from industry, particularly for use in electric light bulbs. A liquefaction research laboratory was established at Elizabethport, in 1921, to study production methods in quality of products.

In 1919 the Company completed acetylene plants at two more locations and oxygen plants at five others. It also organized Cuban Air Reduction Corp. (succeeded in 1920 by Cuban Air Products Co.) to manufacture and distribute oxygen and acetylene in Cuba. In the following year Air Reduction completed two more acetylene plants and an additional oxygen plant. Also that year, it began to expand in the field of related gases, acquiring a controlling interest in the Compressed Carbonic Co. of Baltimore, which it had formed that year with U. S. Industrial Alcohol Co. to manufacture carbon dioxide. This was an important step in the carbon dioxide industry, in which Air Reduction was later to become a leader (Compressed Carbonic was one of the companies incorporated into Pure Carbonic Co. of America when that company was formed in 1929).

The Company ventured also into the carbide field. Up to 1921 it purchased all its calcium carbide. In addition to the importance of carbide in the oxyacetylene process, large amounts were used for making acetylene for lighting and cooking in homes, etc., and it was to have a very important part in chemical synthesis. Air Reduction, therefore, looked around for a dependable supply for these markets and for its own acetylene plants. At Ivanhoe, Va., were ample and remarkably pure supplies of limestone and anthracite coal, providing lime and coke, the two basic ingredients of calcium carbide. Here National Carbide Corp., an independent company formed in 1917, had established a carbide plant. In 1921 Air Reduction acquired this plant of which R. F. K. Tothill was manager. L. A. Hull, who joined Air Reduction in 1917, later became secretary and vice-president of National Carbide, and is now president. Air Reduction's president, C. S. Munson, who came with the Company in 1919, was made vice-president and general manager of the new subsidiary shortly after its acquisition, and later became its president. W. C. Keeley, with Air Reduction since 1920, was at one time vice-president of National Carbide, and is now a director.

The Company's next step was the expansion of its apparatus-manufacturing activities. It had been manufacturing torches and other equipment since 1917 in Jersey City. In 1922, purchase of the Davis-Bournonville Co. acquired an outstanding established line of cutting and welding apparatus and acetylene generators. This company was named for two pioneers in the acetylene industry—Augustine Davis, inventor of the first carbide to water acetylene generator for house lighting, and Eugene Bournonville, who brought from France the process of dissolving acetylene in acetone. By 1922, therefore, Air Reduction was producing as a single manufacturing and selling unit all requirements of the oxyacetylene process. It

concentrated on developing apparatus and supplies for cutting and welding, at a price which would encourage greater use of the process. Different sizes and styles of welding torches were developed as new uses were found for the process. The torches themselves had been improved and considerable experimentation was being done on safety devices, such as water seals and check valves for acetylene pipe line installations in shops and plants. This was the beginning of many safety devices developed by the Company in later years.

In the early days, to sell the oxyacetylene process it was necessary to stage exhibitions and demonstrate visually what Airco equipment would do. Because the idea of welding and cutting with acetylene was new, most industries were hesitant about accepting it, and a Welding Institute in the Jersey City plant had to be equipped for courses in the use of welding and cutting apparatus, which lasted one to four weeks. A commercial welding shop was operated so practical work could be observed by students and customers. By 1923 demonstration plants in other parts of the country were functioning.

Simultaneously the Company continued plant expansions. In 1922 an additional oxygen plant was erected in Milwaukee; oxygen capacity at two other plants was doubled; acetylene plants at Birmingham and Pittsburgh were installed. In 1923 an oxygen plant was erected in Baltimore and another at Sharon, Pa. In Cleveland the capacity of the oxygen plant was increased and production of argon was begun there for use in incandescent lamp bulbs.

An important step in the oxyacetylene industry, because Company research had shown that savings resulted from the increased cutting speed made possible by high-purity oxygen, was the designing of new equipment by Air Reduction engineers and its installation in 1924 at the Company's older oxygen plants, which made possible production of 99.5% pure oxygen, a quality heretofore unknown in commercial production. Through 1924-28 the Company, following its policy of installations near points of greatest consumption, built new plants, enlarged the capacity of others, or acquired already constructed plants. At the end of 1928 it had 28 oxygen plants, 14 acetylene, 1 argon, 1 hydrogen, and 1 carbide.

In 1927, because of its interest in related products, Air Reduction acquired a stock interest in the U. S. Industrial Alcohol Co. (now U. S. Industrial Chemicals, Inc.). As a by-product of this acquisition, Pure Carbonic, Inc., was incorporated in 1929 to operate plants for liquid and solid carbon dioxide, taking into its fold plants in Baltimore, Newark, Chicago, and Berkeley, Calif., with various subsidiary plants in locations near large consuming areas. Through its nominee, Pure Carbide Co. of America, in 1934 it acquired the DryIce Corp. of America—up to that time the largest purveyor in the United States. Pure Carbonic now had available carbon dioxide both in liquid (gas) and solid forms.

In 1931 Charles S. Munson, a vice-president of Air Reduction, was elected president. Up to 1931, Air Reduction had been primarily interested in production of oxygen and acetylene, but that year it acquired a majority interest in the Wilson Welder & Metals Co. (entire interest acquired in 1934) which manufactured electric arcwelding machines, electrodes, and accessories. Air Reduction could then offer its customers either oxyacetylene cutting and welding or electric arcwelding. In 1938 the Arcrods Corp. was formed to manufacture electrodes—based on the joint research and facilities of General Electric and Air Reduction, and jointly owned.

In 1940 Ohio Chemical & Manufacturing Co. was incorporated to [illegible] and operate plants of another company of a similar name for the producti[illegible] nal gases, anesthetic and therapeutic equipment, chemicals, and gla[illegible] was a natural acquisition stemming from the extremely large use [illegible] nal oxygen in hospitals and for other therapeutic purposes.

In 1941 National Carbide constructed its largest carbide and acetylene plant at Louisville, primarily to furnish acetylene to the adjoining plants of du Pont and Goodrich for the national synthetic rubber program. The Company materially increased its plant capacity to meet the needs of the war. Its under-water cutting torches were used in Pearl Harbor salvage operations. Airco designs for trailer trucks adapted for hydrogen and helium were an important contribution to the Army's barrage balloon program. Airco products were used extensively in the nation's shipbuilding program and by railroads and industry. High-altitude masks for flyers were manufactured by the hundreds of thousands. During 1942-43 new plants were installed near industries producing equipment for the war program and in addition, there were built and operated for the Government 7 new oxygen plants and 1 acetylene plant. In the latter part of 1943 were completed 9 oxygen, 44 acetylene, 1 nitrogen, and 1 calcium carbide government-financed plants.

In 1944 Air Reduction acquired the Scanlan-Morris Co. and the Hospital Supply Co. & Watters Laboratories Consolidated, both in the hospital supply and equipment field, which operated as divisions of the Ohio Chemical & Manufacturing Co. Airco Export Corp. was also incorporated to promote sales in foreign lands, giving world-wide scope to the Company's operations. During 1945 the expansion program continued in line with the policy of installing gas-manufacturing plants to serve local areas with a minimum of distribution expense. Since the future growth of Air Reduction as of any chemical company is linked inseparably with an intelligent and progressive research program, at the end of 1945, near Summit, N. J., construction of a new mechanical research laboratory was started. Here will be brought together the research and the development of processes and apparatus for using industrial gases and the electric arc, particularly in the cutting, welding, and treating of metals.

The policies of Air Reduction and its subsidiaries are directed from the home office in N. Y. City, but are implemented by district personnel located at the centers of large consuming areas from coast to coast. To reach the small users, Air Reduction often works with dealers, furnishing them with the latest information on the use and application of its products. The growth record of Air Reduction in the past 30 years shows: 1917, total assets (after depreciation) $7,436,000, net sales $3,187,000; 1947, total assets over $90,000,000, net sales more than $85,000,000. From six employees in the original office the number has grown to approximately 8,300 at the end of 1947. Officers of the Company, Jan. 1, 1948, are: Charles E. Adams, chairman of the board; Charles S. Munson, president; Herman Van Fleet, vice-president and operating manager; Charles D'W. Gibson, vice-president, sales; George E. Hawkins, vice-president, distribution; and William C. Keeley, Lemuel A. Hull, and John A. Hill, vice-presidents.

ALLIED CHEMICAL & DYE CORPORATION was formed in Dec. 1920, to consolidate through stock ownership five large, well-established domestic chemical manufacturers: Barrett Co., coal-tar products; General Chemical Co., acids; National Aniline & Chemical Co., Inc., dyestuffs; Semet-Solvay Co., coke and its by-products; Solvay Process Co., alkalies and nitrogen products.

One of the principal reasons for consolidation was the desire to assist in creating a comprehensive American chemical industry, free of foreign domination, which would make the country independent of foreign sources of essential industrial products, as illustrated by the following excerpt from a letter sent to the stockholders:

"Among the advantages which the Committee believes are to be derived from such a consolidation are: Greater diversification of output and correspondingly greater stability of business; closer adjustment of the production of basic and inter-

mediate materials to the requirements for manufacture and their derivatives; and greater financial strength—not to mention the various economies in operation ordinarily available only to an organization of the scope here contemplated.

"It is, however, in the future development of the chemical industry that the Committee believes the greatest advantages of the proposed consolidation lie. As compared with most of the other major industries, the chemical industry is young. Current developments in this industry are correspondingly more rapid and important that in the older lines of industry, and will probably so continue for many years. For this reason, intensive progressive research is—and will continue—an especially important feature of the chemical manufacturing business. In the opinion of the Committee, the promotion of such research, through combination of the material and personal resources of the consolidating companies, is alone a compelling reason for the proposed consolidation. It is believed that the technical skill, business ability, and financial strength of the consolidating companies, if united, will definitely assure the development of a complete American chemical industry, such as is essential to the industrial independence of the country and to the national security."

Each of the companies included in the Allied consolidation was a leader in its own branch and each had contributed substantially toward the development of the chemical industry in this country. General Chemical originated a method for the production of sulfuric acid by the contact process and was the first to produce contact acid in the United States. It also developed a process for synthetic ammonia, destined to be the basis of the first commercial plant of its kind in this country. This process, as further developed through extensive research, played a leading part in freeing this country from foreign sources of nitrogen.

Solvay Process was the first domestic producer of soda ash and caustic soda. This company also constructed and operated the first by-product coke plant built here. On the basis of this plant, Semet-Solvay led the early development of the domestic by-product coke industry, thus saving vast quantities of materials previously wasted in beehive coke ovens, resulting in many new important products and providing a foundation for the organic chemical industry.

National Aniline, with its predecessors, was the first integrated dyestuffs producer in this country equipped to process coal-tar crudes through intermediates to finished dyes, and it played a large part in relieving the shortage of dyes during World War I. Barrett played a large part in the development of the coal-tar industry in the United States.

While the constituent companies were engaged in different fields and their processes and operations differed, their activities were to a considerable degree interdependent, so that the Allied group constituted an integrated enterprise. Semet-Solvay and its affiliates were engaged in coal mining and the operation of coke ovens, the principal products including coke, ammonia, and coal tar. Solvay Process utilized coke and ammonia, together with limestone and brine from its own quarries and salt deposits, in the production of soda ash, caustic soda, and other alkalies. Coal tar was the principal raw material of Barrett, and from the distillation of this material it obtained naphthalene, benzene, toluene, and other coal-tar crudes. These crudes were used by National Aniline in the manufacture of intermediates which were further processed to finished dyes. Alkalies were used in large quantities by General Chemical in the manufacture of a number of its pr[illegible] National Aniline in the production of intermediates and dyestuffs. Th[illegible] pany was also a large consumer of sulfuric acid, nitric acid, and o[illegible] manufactured by General Chemical.

The consolidation involved no new financing and represented in ef[illegible]

of resources. The preferred and common stocks of the several companies were simply exchanged for preferred and common stocks of Allied, and within a relatively short period after its formation Allied had acquired all of the stock of the consolidating companies.

Following the merger, Allied Chemical & Dye Corp. functioned solely as a holding company, coordinating and supervising the basic policies and activities of the group. The operating companies retained their separate identities and continued to manufacture and market chemical and related products in their respective fields under their own names. In 1941 Barrett Co. and National Aniline, and in 1947 General Chemical, Semet-Solvay, and Solvay Process were liquidated as individual corporate entities. However, their activities have been conducted as previously, as separate divisions of Allied.

Each of the operating companies likewise continued to maintain its own research organization and to operate its own research laboratories. Extensive research was conducted on a broad basis. Supplementing the activities of the operating companies, Allied in 1943 established a central research organization to conduct fundamental and exploratory chemical research. The activities of this group expanded rapidly, although retarded by the shortage of research workers resulting from World War II, and in 1946 construction was commenced on a $1,000,000 laboratory at Morristown, N. J., to house this organization which had outgrown existing facilities.

With a view toward encouraging advanced training in chemistry and chemical engineering, Allied in 1941 established a graduate fellowship plan. In the first year 21 fellowships were offered at 17 universities and colleges. By 1948 the number had been increased to 31 in 24 institutions. Fellowships are awarded to outstanding graduate students who have demonstrated an aptitude for research, the nomination of the fellows and the type of research undertaken being left to the schools.

Since Allied was formed, the growth of the group has been almost entirely from within through the addition of new products, principally developed from research, and increase in the productive capacity of the basic products manufactured by the consolidating companies in 1920: not through acquisition of outside companies. The expansion is reflected by the increase in assets from $282,700,000 at the end of 1920 to $574,000,000 at the end of 1947. Not only was this increase effected without new financing, but at the same time the Company liquidated all funded debt and redeemed all of its preferred stock, paid regular dividends each quarter and in several years special dividends. Following the redemption of the preferred stock in 1936, the only securities outstanding were 2,214,099 shares of no-par value stock, all of which, with the exception of two 5% stock dividends, were issued in exchange for the common stock of the companies consolidated.

While Allied itself was not formed until 1920, the business of the constituent companies and their predecessors extend back for a long period. As these companies continued to operate as independent units, their histories, both before and after consolidation into Allied, are set forth separately below.

AMECCO CHEMICALS, INC., was originally called the American Chemical Products Co., founded in 1918 by Samuel J. Cohen, young chemical engineer honorably discharged from the Army as Lieutenant in the Artillery. Rare synthetic organic materials—biological stains, osmic acid, creatinin, sodamide, and benzyl benzoate—were first produced to satisfy current market needs. Bacteriological stains and dyes were added and eagerly sought by clinical and research labora-

tories. Cohen had not only to do the manufacturing, but also to search the literature for formulas, about 1,000 of which were compiled.

Stains and dyes were sold in bulk to dealers who merchandized them under their own labels. When biological stains began to be manufactured by companies with direct merchandising programs, the Company sold the stain business to Biosol Products and focused its attention on the manufacture of reagent and research chemicals. Dealer and jobber contacts already established marketed the products. Over 200 synthetic chemicals were prepared during 10 years and intensive research was conducted on many of them because of the promise of large-volume application. Next came a weeding-out period, together with concentrated study of those products already produced in quantity, which not only effected better quality but reduced costs through better know-how.

In 1920 the manufacture of capryl alcohol was taken up. The best process gave a yellow-colored product with a rather disagreeable odor which sold for $16 per lb. Months of research finally evolved a method for large-scale production of a water-white capryl alcohol having a clean, mild odor and sold for a fraction of the old price. A by-product of this process was sebacic acid, selling in 1919 for about $30 per lb. Today, this product made by Hardesty Chemical in Dover, O., is almost C.P. in quality, is produced on a tonnage basis, and sells at a very low price. Cohen was a pioneer in chlorinated paraffins in 1919. A small vial of viscous honey-colored product traveled with him in his coat pocket and there was much discussion of possible commercial uses. In 1932 this chemical sprang from pilot plant to large-scale production with the discovery of its use for making extreme-pressure lubricants. In 1933 arrangements were concluded with Hooker Electrochemical Co. for the commercial manufacture of chlorinated paraffins and acetamide by processes engineered by Cohen and Hooker, Cohen becoming exclusive sales agent for these products for several years and pioneered and developed markets for them.

In 1919 the first manufacturing processes were housed in a small brick building covering 500 sq. ft. and moved several years later to a two-story brick building containing 5,000 sq. ft. space. In 1935 the Company purchased a plant on Rockwood St., Rochester, N. Y., with two acres of ground, on the N. Y. Central R. R. siding, and several cement-block buildings with floor space of 10,000 sq. ft. and 85,000 gal. tank storage capacity. More buildings were constructed to a total of 70,000 ft. and tankage increased.

In 1937 American Chemical Products became Amecco Chemicals, Inc. In 1939 Amecco joined with W. C. Hardesty Co. in building a plant for sebacic acid and capryl alcohol at Dover, O. This operation became the Hardesty Chemical Co. in 1944, with S. J. Cohen president and technical director, and Howard M. Abbott vice-president in charge of sales and production. Expansion was undertaken in plasticizers for vinyl resins and synthetic rubber and plastics. During World War II, Amecco Chemicals produced at Rochester more than 1,000,000 lb. chlorinated paraffin per month. This was chiefly used for fireproofing canvas, tentage, and uniforms for the Army, Navy, and Air Forces.

In 1945 the Rochester plant was sold and all equipment, including research laboratory and plant machinery, freighted 3,200 miles to Henderson, Nev. The huge magnesium plant built during the war by our Government at a cost of $125,000,000 was idle and Amecco occupied Unit #2, one of the 10 main buildings which was served with chlorine by a 10-in. pipe main. Amecco has spent more than $500,000 in the last two years in reconstruction, new installations, and starting operations for the production of synthetic chemicals from chlorinated organic materials. The Stauffer Chemical Co., which operates a chlorine plant and caustic soda unit in one of the main buildings, and the basic plant supply Amecco with chlorine and liquid

caustic soda by pipe line. Since Henderson enjoys excellent dry weather throughout the year, some of the chlorination equipment is built completely outdoors. Raw materials from coal tar and petroleum-base materials are shipped in from the Los Angeles area and from the Utah mills. The plant is now manufacturing *o*- and *p*-dichlorobenzene, monochlorobenzene, and Ameccol, a synthetic detergent. Amecco's chlorinated paraffin is also being made, in 42% and 70% grades, for fireproofing paint bases, and a Western source of supply for chlorinated paraffin is thus well located for this market.

The officers of the Company are: Samuel J. Cohen, president; Mrs. J. G. Cohen, vice-president in charge of personnel; Raymond Heilpern, vice-president and counsel. The stock ownership is held entirely within the family. A son, Robert, is a chemical engineer working in the plant. Amecco Chemicals, Inc., in 1947 is again in the midst of a pioneering operation both from the standpoint of developing a new distribution area of chemicals for the West and Midwest, and for the production of many new basic chemicals. The New York offices originally located at 42 E. 42nd St., have been moved to Los Angeles to serve the West Coast market, under sales manager Samuel J. Cohen.

AMERICAN AGRICULTURAL CHEMICAL COMPANY (Delaware) with head offices at 50 Church St., N. Y. City, is one of the larger producers of phosphate rock, sulfuric acid, superphosphate, and mixed fertilizers, and in addition makes a number of chemical products for industrial use. It was organized in Connecticut in 1899 to acquire and operate a number of the strongest and best-equipped fertilizer plants in the Northern and Eastern states. Subsequently plants in the South and Middle West were acquired. Extensive phosphate deposits in Florida were purchased at various times. The Connecticut company operated continuously until the end of 1930, at which time the Delaware company purchased all of its assets and assumed its liabilities, dissolving the company in 1935. Over the years these properties have been welded into a comprehensive service to agriculture in areas east of the Rockies.

Since 1933 the company has also been expanding its non-fertilizer business. In 1935, one of the first large electric furnaces for producing phosphorus in this country, was built at South Amboy, N. J. Through research and development, products from phosphate rock have been steadily increased, so that the Company now manufactures yellow and red phosphorus, phosphoric acid, monocalcium, dicalcium, and sodium phosphates, ferrophosphorus, and phosphorus sulfides. It also produces magnesium, zinc, and ammonium fluosilicates as by-products in the manufacture of superphosphate.

When the predecessor company was organized in 1899, it took over Bradley Fertilizer Works, Boston and Los Angeles; Listers Agricultural Chemical Works, Newark; Leibig Manufacturing Co., Carteret, N. J., and Wilmington, Del.; Michigan Carbon Works, Detroit; Williams & Clark Fertilizer Co., Carteret; Tygert-Allen Fertilizer Co., Philadelphia; Lazaretto Guano Co., Baltimore; Alexandria Fertilizer & Chemical Co., Alexandria, Va.; Crocker Fertilizer Co., Buffalo; and Cleveland Dryer Co. In addition to fertilizers, several of these companies also produced bone black, ivory black, gelatin, glue, sulfuric acid, tankage, grease, and allied products. In 1903 the Bowker Fertilizer Co. with fertilizer factories at Brighton, Mass., Bayway, N. J., and St. Bernard, O., was acquired. This company also manufactured agricultural insecticides.

In 1902 the Peace River Phosphate Mining Co., which owned some 90 miles of property on the Peace River in Florida, was acquired. In 1905-6 other valuable phosphate properties were purchased in Polk County, Fla., thus providing an

ample future source of supply. Properties at Pierce, Fla., now produce all of the phosphate rock used by the Company. In 1905 the Company built the Charlotte Harbor & Northern R. R. from Arcadia, Fla., to South Boca Grande on Gasparilla Island, Fla., for transporting phosphate rock from its mines to tidewater, and also a deep-water loading terminal. In 1912 the railroad was extended over 100 miles to Pierce and Mulberry, Fla. It and the phosphate-loading terminal were sold to Seaboard in 1925. In 1917 the Company acquired large reserves of high-grade phosphate rock in Hillsboro County, Fla., and is at present operating both high-grade and standard-grade mines.

In 1906-13 the Company expanded in the South by purchasing the well-established fertilizer plants: Ashepoo Fertilizer Works, Charleston, S. C., Bigbee Fertilizer Works, Montgomery, Ala., Goulding Fertilizer Works, Pensacola, and large plants were built at Norfolk, Wilmington and Greensboro, N. C., Columbia, S. C., Savannah, and Jacksonville. During this period additional plants were purchased in Northern and Eastern states. In 1908 the first fertilizer plant in Cuba was established by the Company on Havana Harbor. By 1920 the Company was operating 3 phosphate mines, 39 fertilizer plants, 15 chemical and other types of plants. At about this time, its Agricultural Service Bureau, through field experiment work, aided in the introduction and use of fertilizer in Western states, with resultant improvement in crop production.

In 1931 the Company formed a Canadian subsidiary, Agricultural Chemicals, Ltd., which operates fertilizer plants at Port Hope, Ont., and Chambly, Que., and at this time retired from the tankage and grease business and sold all its rendering plants. The Company has integrated its factory facilities so that at present (1948) it is operating 25 plants at selected locations. It has expanded its other-than-fertilizer business in products stemming from phosphorus and superphosphate production. Complete fertilizers are marketed under the registered trade-marks Agrico and AA Quality. Superphosphate is marketed under the brand name, 18% Normal. Chemical products are distributed under the AA Quality trade-mark. Products currently manufactured are Florida pebble phosphate rock, commercial fertilizers, superphosphate, Agrinite tankage, agricultural insecticides (including Pyrox, lead arsenate, calcium arsenate, etc.), bone black, tri- and disodium phosphates, phosphorus (red and yellow), ferrophosphorus, phosphoric acid, phosphorus pentasulfide, phosphorus sesquisulfide, bone black pigments (Cosmic black), bone ash, bone oil, salt cake, gelatin, di- and monocalcium phosphates, sulfuric acid, ammonium carbonate and fluosilicate, magnesium and zinc fluosilicates.

Present officers are Louis H. Carter, president; George H. Fick and Anthony B. Arnold, vice-presidents; Arnold W. Cramer, comptroller-secretary; William H. Nicholas, treasurer. Directors are, in addition to Carter and Fick, George C. Clark of Clark, Dodge & Co., John R. Dillon, John Foster Dulles of Sullivan & Cromwell, Robert G. Stone, and John C. Traphagen, Bank of New York and Fifth Avenue Bank.

AMERICAN ANILINE PRODUCTS, INC., had a modest beginning. Its foundation was laid by the individual effort and vision of Bernard R. Armour who financed and operated the business alone until Jan. 1909, when the name Swiss Colors Co. was adopted.

When the European war severely curtailed the importation of dyestuffs in 1915, Armour, among others, foresaw the development of a dyestuff industry within the United States. Having been joined in the business by his brother, George L. Armour, a staff of chemists and engineers was employed and manufacturing began in a small but well-equipped plant in Harrison, N. J. It was here that the first

products of the company were successfully made: p-phenylenediamine (a fur dye) and Amacid red 3B concentrate (a prototype of alpine red 3B). The latter is still being manufactured in quantity. The growth of the business was rapid and an additional manufacturing plant and laboratories were set up at Nyack, N. Y.

Having reached a substantial position in the dyestuff and chemical field, the Company was incorporated under the laws of the state of New York, Nov. 16, 1917, under name of the American Aniline Products, Inc. The name of Swiss Colors Co. was abandoned. The original incorporators, directors, and officers were: Bernard R. Armour, president and treasurer; George L. Armour, executive vice-president; F. William Weckman, secretary; and Robert P. Gould, assistant secretary.

The Nyack works was completely destroyed by a disastrous fire in 1919, but a new site was quickly located in the same year. The Corporation acquired the plant of the Stanley Aniline Works at Lock Haven, Pa., where abundant water and coal were available. Manufacturing was soon resumed on an expanded scale and larger research and analytical laboratories were built. In rapid succession the Corporation marketed a range of dyes covering the entire azo color field, trade-named Amanil, Amacid, and Chromaven.

In 1925 the American Cellulose & Chemical Manufacturing Co., Ltd. (now the Celanese Corp. of America), asked American Aniline to research and develop dyes that would be effective on cellulose acetate fiber, then compartively new to the American market. Additional research staff was employed and plant facilities were erected, with the result that a full assortment of colors was made available under the trade names of SRA and Amacel.

During the depression years of the 1930's, the Corporation not only maintained a stable financial position, but hired more chemists to develop colors for the rayon fibers that were coming into the textile markets in increasingly large quantities and with varying physical properties. Despite these difficulties the chemists were successful and the Formanil (formaldehyde-after treated) colors were soon ready for distribution.

In this same period part of the Company facilities was directed toward the production of improved dyestuffs in the so-called "fast" colors, the naphthol and vat range. The first of these was Amanil naphthol AS which was released in 1935. Fast-color salts and bases were also produced. These and other related dyes are now universally exported in addition to a large domestic consumption.

The Corporation's vat color division was spurred to greater efforts by the demand, arising from this country's entry into the Second World War, for "war vats" and many of their scarce intermediates. The major portion of the Corporation's products was consumed by textile dyers engaged exclusively on military contracts. In close cooperation with the Chemical Warfare Service, the Corporation became a large producer of smoke-coloring dyes for use in artillery shells and hand grenades. Many of its chemists joined the CWS upon the battlefields.

Further plant expansion, now covering 35 acres, was necessary during the war years, and this was entirely financed from American Aniline's funds. Continued research and development has extended the Corporation's growth into the entire field of dyestuffs and colors. Modernization of the Lock Haven works has been kept up; all the original buildings have been replaced by new, multistoried structures. In addition to the control and research divisions at Lock Haven, similar laboratories and a research staff are maintained at 66 University Place, N. Y. City, in company-owned buildings. These buildings also provide extensive warehouse facilities.

Executive offices since 1935 have been located at 50 Union Square in N. Y.

City. Prior to this they were at 80 Fifth Ave. and 45 East 17th St., respectively. The Corporation distributes its products direct to the consumers and maintains its own sales organization under the direct supervision of George L. Armour. Branch sales offices, each supervised by a local manager, together with warehousing facilities and application laboratories, are maintained in Boston, Providence, Philadelphia, Charlotte, Chattanooga, Chicago, and Los Angeles. The Canadian trade is served through a wholly owned subsidiary, the Dominion Anilines & Chemicals, Ltd., with offices, warehouses, and application laboratories in Toronto and Montreal. The subsidiary has its own corps of salesmen.

Bernard R. Armour and George L. Armour have guided the Company during almost four decades of successful growth closely paralleling the rapid development of the dyestuff industry in the United States.

AMERICAN BEMBERG CORPORATION was incorporated on July 14, 1925, in Delaware, by Vereinigte Glanzstoff Fabriken A.-G. and its affiliate J. P. Bemberg A.-G., rayon manufacturers of Germany, which latter made its patents and processes for the manufacture of cuprammonium rayon yarn available to the new company. In 1929 the two German companies became subsidiaries of Algemeene Kunstzijde Unie, N. V., rayon manufacturers of Holland. Initial capitalization consisted of $3,500,000 of 7% preferred stock and 140,000 shares of common. The first factory unit was built in 1925-26 at Elizabethton, Tenn., with a planned capacity of 1,800,000 lb. yarn per annum. Construction of a second unit was commenced in 1927 and completed in 1929, financed by the sale of 140,000 shares of common stock, Class B. As a result of this addition, plant capacity totaled about 4,300,000 lb. per annum.

The Company's product has been exclusively rayon yarn made by the cuprammonium stretch-spinning process and sold under the registered trade-mark "Bemberg" to the textile trade throughout the United States. Bemberg rayon yarn is especially adapted for use in sheer dress and underwear fabrics; underwear satins; neckwear, tricot, and milanese knitted goods for underwear, gloves, and outerwear; circular-knit brushed fabrics, linings, and drapery; and upholstery fabrics. Its production cost is comparatively high, but as a specialty product its reputation has become firmly established. Multifilament yarns can be produced very advantageously, especially in the finer deniers. The principal raw materials used are high-grade purified wood pulp, copper sulfate, ammonia, caustic soda, and sulfuric acid.

Since 1929 plant capacity has been increased to 13,500,000 lb. per annum, financed entirely out of the Company's own resources. Recently, new manufacturing equipment has been developed which will produce yarn of much better quality, and an initial installation now being made will add 850,000 lb. to present annual capacity. American Bemberg Corp. has the same directors and officers as North American Rayon Corp. The plants of both companies are located near each other and a number of departments are operated jointly.

In Aug. 1947 the majority stock interest in the Corporation owned by Algemeene Kunstzijde Unie, N.V., Vereinigte Glanzstoff Fabriken, A.-G., and J. P. Bemberg, A.-G., was vested by the Office of Alien Property of the U. S. Government, as a result of an agreement reached with the Netherlands Government and Algemeene Kunstzijde. It is anticipated that eventually the Office of Alien Property will dispose of this controlling stock interest in this country.

AMERICAN-BRITISH CHEMICAL SUPPLIES, INC., was established in 1924, in New York, to take care of a rapidly expanding business in the United States, the foundations of which had been laid by Charles Tennant & Co., Ltd., of Glasgow, a city which 150 years earlier had carried on a lucrative trade with what were then the American colonies. The Company is thus in direct descent from Charles Tennant, founder of the first Tennant Co. at St. Rollox in 1797. Until the introduction of the McKinley Tariff, St. Rollox carried on an active business in bleaching powder and soda ash with the United States. The opening of an office in New York owed a great deal to its first vice-president, William McC. Cameron, and to its first manager, Edwin H. Watson, who died in its service in 1939. The management is now in the hands of John T. Ames, president, who is also in charge of the Canadian interests. Other officers are W. McC. Cameron and G. W. Dyne, vice-presidents, and W. A. Anderson, secretary-treasurer.

To trading activities in chemical fields—export, import, and domestic—the Company soon added others. It acted as chemical purchasing agent for the Celanese Corp. of America and Canadian Celanese, Ltd.; became a factor in the domestic and imported casein market for the paper trade; and today acts as purchasing agent for many companies. Direct sales agencies are maintained for such general chemicals as alkalies, alcohols, acetone, and other solvents. The Company operates its own manufacturing facilities. Its foreign business has grown, through its cooperation with the other Tennant interests, so that it is now represented in almost every foreign country. Last year, 1947, it celebrated the 150th anniversary of the founding of the Tennant group of companies.

AMERICAN CHEMICAL PAINT COMPANY was started at 1126 S. 11th St., Philadelphia, by J. Harvey Gravell and was incorporated Feb. 24, 1914. Gravell had been in the experimental department of a sheet-metal plant and became aware of the need for better rust removal from these products in preparing them for painting.

At that time many painters felt that a perfectly polished surface was all that was necessary for a durable finish. This was far from the truth, for these surfaces often contained rust-forming chemicals that only needed time to develop blisters of rust beneath the elaborate system of paint coats. A means of correcting this had been discovered and was the subject of a patent Gravell and the Company acquired. Though simple, it made it possible to clean the sheet metal so that the harmful effects of soldering, handmarks, etc., were destroyed. In litigation of this patent some years later, Judge Buffington in the Court of Appeals commented that this development made the steel automobile possible. Gravell mixed his concoction, called Deoxidine, with a bucket and a broom, and then went to Detroit to sell it to the automobile body builders. Success at first was slow; finally tests proved that Deoxidine-cleaned bodies did not develop rust and carloads of it were regularly used in this as well as in other sheet metal-fabricating and finishing industries. The name, American Chemical Paint Co., is not entirely descriptive, for this company is not a paint manufacturer, but all its early developments were involved in the painting process as a treatment prior to paint application.

In 1921 Gravell conceived the idea of making an addition to the acids commonly used in pickling steel to prevent the attack of the metal in the process of removing heat scale. Hundreds of test tubes were filled with pickling acid and a nail and everything Gravell could lay his hands on was added until he found types of material which arrested the acid's action. Out of this came another series of chemicals

named Rodine, used and still being used almost universally throughout the steel-pickling industry the world over.

Other chemicals were developed in the research laboratories to do chemically at low cost what labor was required to do elaborately and less effectively. Special soldering acids made it possible to solder sheet metal through a coat of oil and a combined chemical and oil had the effect of the Deoxidine cleaning with the application of a protective oil film at one time. Another product, Lithoform, developed a coating on galvanized iron which prevented the shedding of paint so characteristic of this metal. The development of a phosphate coating on zinc with Lithoform started a new chain of experiments which pioneered the development of phosphate coatings on steel itself and led ultimately to the first treatment of sheet-metal parts for the automobile in a continuous, labor and time-saving spray process, and to the development of the phosphate coating products of the Company.

Research facilities expanded from a single chemist to the present staff of many research and control chemists with well-equipped laboratories devoted to the investigation of metal-treating chemicals and processes.

In 1938 the Company became interested in the manufacture of chemical hormones that improved the rooting of seeds and the growth of transplanted products. Later other chemicals were made which when sprayed on ripening fruit caused it to cling longer to the tree. The laboratory developed other horticultural products and pioneering work was done in the development of 2,4-dichlorophenoxyacetic acid, now so well known as 2,4-D. Later several large companies entered the field and are now manufacturing and distributing products for weed eradication, many of them operating as licensees under American Chemical Paint patents.

In the depths of the depression the Company became interested in the scouring of wool. A process was developed in which these scouring liquors were settled, centrifuged, and returned to the scouring system in the course of which sediment and dirt were discarded, wool grease separated and saved, and the scouring liquor, with a considerable amount of alkali and soap left in it, returned to the scouring train for further use. Additionally, an instrument named the Ridometer was perfected which made it possible quickly and accurately to determine and control the concentration of alkali in the scouring liquors. Another device, named the Greasometer, which simplified and speeded the determination of the residual grease in the wool and in the scouring liquor itself, was developed and is widely used. In licensing scouring plants to use this process, the Company took as royalty part of the crude wool grease previously discarded. From this, through a purifying process, U.S.P. lanolin is manufactured and an elaborate plant has been set up for the recovery of cholesterol, from which sex hormones are manufactured.

In 1945 marked increase in the use of aluminum led the Company research laboratories to investigate treatments for this metal. A chemical named Alodine was developed which is used nonelectrolytically with an application time of two minutes or less and with results that compare most favorably with those obtained by elaborate and costly processes. A new type of Alodine provides excellent protection for aluminum by brush application to large assembled structures.

The Company has grown from three men, operating with a few hundred square feet of floor space, to an organization of several hundred with a plant comprising 14 buildings, with over 1,000 sq. ft. of floor space and over 50 acres. A warehouse with a technical service organization is established in Detroit. The Company's products are manufactured in Canada in a modern plant at Windsor, Ontario. Its agricultural chemical products are distributed all over the United States and are being manufactured and distributed in practically all the countries of the world. For many years the Company has been represented in most foreign countries by

licensees who manufacture its products under the Company's formulation and guidance.

AMERICAN CHLOROPHYLL, INC., was a slow starter, for we read in Genesis I:11 that the first living organic substance was grass. It made life on earth possible. It was under our feet everywhere, and yet there was no intensive chemical research on green vegetation until Willstätter published his comprehensive work on chlorophyll in 1913.

Research on chlorophyll was started in 1917 at the U. S. Fixed Nitrogen Research Laboratory, near the site of American University, and was continued there until translated into a commercial undertaking by American Chlorophyll Co. in the summer of 1934, a year after its founding.

In 1928 a conference to consider the promotion of chlorophyll in a medicinal way was called by Arthur T. Vanderbilt, later president of the American Bar Association. At the instance of some New York clients, he invited Dr. Alfred S. Burdick of Abbott Laboratories, C. E. Jamieson of C. E. Jamieson & Co., and Robert H. Van Sant of the Anacin Co. The promoters advanced their project for which they had negotiated a license for United States rights. Chlorophyll was the active ingredient and in tablet form was suggested for secondary anemia, with many other claims. But clinical background was lacking, nor was the plan of operation feasible or compatible with the development of a new medicinal product in the American field. The guests were not impressed by the flattering proposals and all three declined; no further discussions were had.

In 1930 Van Sant, with his associates, sold the Anacin Co. to American Home Products, Inc. He moved to France, primarily to place his son and daughter in school, and not being accustomed to leisure, undertook an investigation of the therapeutic qualities of chlorophyll in Switzerland, Germany, Italy, and England. He became convinced that chlorophyll had strong chances of success in medicine because of its ability to embrace in organic form mineral elements otherwise crudely used, often with toxic results.

Early attempts to prepare these mineral compounds failed. But the attitude of the Washington authorities toward Van Sant's undertaking convinced him that production of chlorophyll in the United States was of first importance and that the availability of research grades for clinical use would ultimately result in a wide diversification of applications and acceptance of the product. On these convictions American Chlorophyll Co. was formed in May 1933 to produce and refine chlorophyll, carotene, and xanthophyll for research, and sell commercial grades.

A site was leased from the District of Columbia Paper Co. at Georgetown, opposite its plant on the C & O Canal, giving the Company buildings and frontage on the Potomac River. Pilot equipment was installed, but soon torn down and rebuilt for further experiments. The Company chose its site near the Department of Agriculture Chlorophyll Laboratory, headed by Dr. Frank M. Schertz who had been assigned this work in 1917 with a view to laying a foundation for commercial production in the United States. After a year's experiments, the Department of Agriculture decided that the infant industry could crawl and suggesed that Dr. Schertz' full-time services be transferred to the American Chlorophyll operation.

American-made chlorophyll, carotene, and xanthophyll were soon in distribution in pure concentrations, and institutions, particularly universities, were invited to experiment with the research grades. One sample of 5X chlorophyll, 99% pure, was sent to Dr. Hans Fischer of the University of Munich. After tests he wrote a most flattering letter and placed an order for 1,000 grams. But Hitler ruled otherwise; the license for importation was refused. Experimental operations con-

tinued, but the expense of growing and harvesting Company-owned raw material and the losses incurred in processes made a commercial undertaking unfeasible from this source.

While on a trip to Chicago, Van Sant chanced on a supply of extremely rich dehydrated leaf meal (alfalfa). This was traced to the point of origin and test runs proved its possibilities for large-scale production. Larger plans were drawn and initial equipment built, but more capital was needed. Through efforts of Mrs. E. D. Leach and George L. Bell, former vice-president of Caterpillar Tractor Co., associates of J. Henry Schroder Banking Corp., New York, made possible the enlargement of facilities and working capital, and American Chlorophyll Co. was incorporated in Delaware as American Chlorophyll, Inc. The officers were Van Sant, president; Bell, vice-president; Mrs. Leach, secretary; Whitney H. Shepardson, treasurer. Shepardson, then managing director of International Railways of Central America, has since become a trustee of the Carnegie Foundation. Mrs. Leach later succeeded him as treasurer. With this change, the officers as originally elected have continued into 1948.

In 1936 the plant at Georgetown experienced a severe flood, followed by a serious fire on May 9. Immediate steps were taken to relocate outside the city. Fortunately the plant of the Virginia-Carolina Chemical Co. on the Potomac in North Alexandria, Va., stood idle. Its lease and purchase of approximately seven acres with warehouses and spur track were rapidly consummated. Several more fireproof buildings were erected and the plant resumed operations in time to fulfill its budding contracts. In spite of German competition and Reichsmark subsidies, the Company secured all the contract business in the United States and Canada, and still enjoys it in technical uses of soaps and cosmetics.

From 1937-39 the Company had little success in its researches. Further contributions of capital were not justified. It tightened its belt. While from 1934 it had furnished certain derivatives that led to the development of formulas by others, it continued to preserve a strictly ethical attitude in the aid of these developments, some of which now promise to gain national acceptance.

Dr. Schertz, who was highly regarded as a plant physiologist, was handicapped by lack of engineering training in equipment layouts for commercial production, and 1939-42, the Company was largely concerned in improving its commercial grades. Substantial efficiencies were realized and the volume of sales grew. But with the advent of the war the picture changed. Considerable effort was spent in assisting experiments and furnishing materials for camouflage projects, but this work never went beyond the experimental stage. Personnel fell off due to the draft. The enterprise was in the war, but of no real assistance to the war effort. One project, the utilization of its processes for large-scale production of carotene gained considerable momentum, but as a result of departmental shifts in Washington, was abruptly terminated. The war period was a trying one. OPA ceilings brought about a dilution of alfalfa meal to low values where costs became prohibitive. The uses of chlorophyll and its companion products were not recognized as essential to war needs. Sales fell off alarmingly.

Some work was then attempted in connection with processes for caffeine, including conversions, and the plant was qualified in a small way to supply it. At the solicitation of the Coca-Cola Co., a plant was built at Beaufort, N. C., to extract caffeine from maté. An initial shipment of some 600 tons of this raw material was allowed to enter through New Orleans, after which further shipments were embargoed. This shipment proved to have only 50% of the caffeine [illegible] purchase samples analyzed, and the plant yields were correspondingly reduced. Alternative material was unobtainable in sources of cocoa meal, tea, and [illegible]

Further operations for caffeine became impossible and the Coca-Cola contract was terminated by mutual consent.

With the end of war conditions in 1946 the Company was able to reestablish its laboratory personnel. By virtue of its extensive experience and the return of some of its men from war service, it has been able to enter a new and extended phase of development. With some 30 derivatives at its command, the processes have been completely revamped to the point where hitherto unattainable grades with light-fast properties and many new metallic derivatives are offered for chlorophyll therapy.

In 1948 the Company purchased a 15-acre site at Lake Worth, Fla., on the West Palm Beach Canal and Florida East Coast R. R. With enlarged and improved facilities, operations will be extended utilizing Florida-grown vegetation from the Lake Okeechobee area within easy handling distance. Executive offices and works are permanently located at Lake Worth. Dr. Walter H. Eddy, emeritus professor of biochemistry at Teachers' College, Columbia University, is scientific director.

AMERICAN CYANAMID COMPANY was organized in 1907 by Frank S. Washburn, an American civil engineer, to manufacture calcium cyanamide by the Frank-Caro nitrogen-fixation process. This process combined atmospheric nitrogen with calcium carbide at 2,000° F. to form calcium cyanamide, a rich source of fertilizer nitrogen. Washburn, sensing its commercial possibilities, founded Cyanamid as the first company in America to produce calcium cyanamide. The original officers, in addition to Washburn, president, were Charles H. Baker, vice-president-treasurer, Isaac W. Read, secretary, and Millard W. Baldwin, clerk.

Tremendous power and an unlimited source of limestone were important factors in the process and influenced the choice of the Company's first plantsite. The Muscle Shoals location in Tennessee was Washburn's immediate choice, but when negotiations for power rights failed, he turned to Niagara Falls and discovered the ideal location on the Canadian side. Plant construction began promptly and in 1912 calcium cyanamide was in production. Expansion began in 1916 when the Company acquired the Ammo-Phos Corp. of Warners, N. J., and the Amalgamated Phosphate Co. of Brewster, Fla. The following year production was begun on Ammo-Phos ammonium phosphate, a fertilizer product combining liquid phosphoric acid manufactured at Warners, and nitrogen derived from crude calcium cyanamide manufactured at Niagara Falls. (Ammo-Phos production was discontinued in May 1941, because of dislocations caused by World War II.) At present Warners manufactures sulfuric, hydrochloric, and hydrocyanic acid; Rezyl resins, Phenac and Teglac resins for the paint, varnish, and lacquer industry; lubricating oil additives; rubber accelerators; dicyandiamide; and many other industrial chemicals.

In 1922 W. B. Bell became president and the Company instituted a program of diversification which projected it into practically every branch of the chemical field, accounting largely for its continued progress.

In 1929 the Calco Chemical Co., Bound Brook, N. J., was acquired and operated as a separate corporation until 1939, when it became a division of American Cyanamid Co. Calco has seven plants, three in New Jersey, two in Virginia, one in Ohio, and a new one under construction in West Virginia. These manufacture and sell dyestuffs, intermediate chemicals, pigments, textile resins, pharmaceuticals, household products, and rubber chemicals. Dyestuffs for textiles, paper, leather, gasoline, woodstain, carbon paper, food products, furs, cosmetics, and other products are made at the main plant in Bound Brook; at a recently acquired plant in Marietta, O.; and at Damascus, Va., the latter plant specializing in sulfur dyes for cotton yard goods and alizarin red for printing inks. Intermediate coal-tar products and mineral acids are produced at Bound Brook.

Most products of the Pigment Department are produced at Bound Brook and Newark, N. J. However, some are produced at Willow Island, W. Va., and titanium dioxide is processed at Piney River, W. Va., and Gloucester, N. J. The Textile Resin Department supplies various synthetic resins for finishing purposes, including Lanaset resin, applied to woven and knitted wool fabrics; Sheerset resin, based on melamine, as a lasting crisp finish for cotton and rayon sheer fabrics; Lacet resin, as a stiffener for cotton and rayon Nottingham lace curtains; Aerotex softener H, a synthetic softener for wool, cotton, or synthetic fibers; Superset resin, applied to woven rayon and acetate fabrics; Permel resin, a water repellent for synthetics, cotton, and wool. The Pharmaceutical Department produces bulk pharmaceuticals, vitamins, sulfa drugs, and pharmaceutical pigments at the Bound Brook plant and will also produce them at the new Willow Island, W. Va., plant. The Household Products Department produces a packaged laundry bluing, Bleachette, at Bound Brook. Rubber chemicals are produced mainly at Bound Brook, although some few items are manufactured at Warners. Products of this department include rubber accelerators, activators, and intermediates, and rubber sulfur.

The business of the Selden Co. of Pittsburgh, Pa., was also acquired in 1929. The plant at Bridgeville, Pa., is a major producer of phthalic anhydride, synthetic resins, and sulfuric acid catalyst. It also produces wetting agents, leather chemicals, and synthetic plasticizers. One of the largest makers of phthalic anhydride, this plant supplies all Cyanamid's requirements, as well as a substantial tonnage for sale to other users. In addition, Bridgeville produces synthetic resins used in a variety of paints, enamels, varnishes, and lacquers. Here in 1936 and 1939, respectively, was pioneered the commercial production of Beetle and Melmac, thermosetting resins which speed up industrial production lines by cutting enamel-baking time. They are respectively condensation products of urea and melamine with formaldehyde, alkylated with appropriate alcohols. Rezyl resins, principally phthalate alkyds, are of oxidizing and nonoxidizing types, both of which serve as plasticizers.

In 1929 Cyanamid also acquired the Kalbfleisch Corp., one of the oldest industrial chemical companies in America. The name was changed in 1932 to American Cyanamid & Chemical Corp. and to this new subsidiary were transferred many of the technical services and the production and sale of many industrial chemicals. It was operated as a separate corporation until July 1946, when its business was turned over to American Cyanamid Co. and is now operated as the Industrial Chemicals Division. A wide range of industrial chemicals produced at Warners, Bridgeville, and other plants are sold by this division, including the entire production of two textile chemical plants bought by Cyanamid after the acquisition of Kalbfleisch. One was located at Woodbridge, N. J., the other at Charlotte, N. C., producing sulfonated oils and fats. Woodbridge adds to the list of products refined vegetable waxes, metallic soaps, and Cutrilin bate used in treating leather. Also included in the Industrial Chemicals Division are seven alum plants located in Chattanooga, Warners, Georgetown, S. C., Joliet, Ill., Kalamazoo, Mich., Mobile, and Hamilton, O. Three of these plants make other chemicals: Mobile produces sulfuric acid; so does Joliet, which also makes muriatic acid, sodium aluminum sulfate, and sodium aluminate. Kalamazoo produces liquid alum, sulfuric acid, wax sizes, and caseins for paper manufacture. Another three plants supply bauxite for the seven alum units: the Berbice River plant in British Guiana, the Andersonville unit at Andersonville, Ga., and the plant at Berger, Ark. Also at Berger i[illegible] Porocel Corp., jointly owned by Cyanamid and the Attapulgus Clay Co. Po[illegible] produces activated bauxite, adsorbents, catalyst carriers, supported catalysts, iccants, etc.

A Cyanamid plant at Azusa, Calif., supplies hydrocyanic acid for fumigati[illegible]

citrus fruit, as well as insecticides, fungicides, and rodenticides; flotation reagents; resins; and chemical specialties for the conditioning of drilling muds. Cyanamid also produces a new fluid catalyst for petroleum refining at Forth Worth, Tex. At Valdosta, Ga., and Waterbury, Conn., two Cyanamid plants produce rosin size for paper and, in addition, the latter manufactures catalysts for the production of hydrogen for ammonia synthesis, for the synthesis of ammonia itself, and for the reforming of such gases as methane. A Cyanamid plant at Baltimore makes sal soda and two plants located at Latrobe and New Castle, Pa., produce between them a line of industrial explosives and blasting accessories.

American Cyanamid activities in plastics began with its introduction of urea resins in 1929 and with the acquisition of rights to produce and market urea-thiourea-formaldehyde-type molding materials. Cyanamid was the first concern in the United States to manufacture these products, known as Beetle plastics. During the 1930's urea-formaldehyde resins were modified for use as laminating resins. They were also found to have excellent bonding characteristics and, toward the end of the decade, a line of resin adhesives was introduced. Today, Beetle molding compounds and Urac resin adhesives are produced at Bound Brook and in a rapidly expanding plant at Wallingford, Conn. Cyanamid was also a pioneer in melamine-formaldehyde plastics. Within the past few years it has developed a series of polyester laminating resins. In addition to plastic resins, Cyanamid produces Ionac ion-exchange resins, synthetic resins capable of both anion and cation exchange. The increased demand for plastics since 1940 has induced the Company to expand greatly its manufacturing facilities at Wallingford, while additional facilities at Bridgeville and Willow Island are under construction.

In the mining field, Cyanamid is engaged in mining limestone in Canada for the calcium cyanamide process and for sale to agricultural and industrial consumers; the mining operations at the bauxite plants; and the Cyanamid unit at Brewster, Fla., where phosphate rock is mined, washed, screened, and graded for use in superphosphate or for direct application to the soil.

The Mineral Dressing Division manufactures and sells chemicals and processes for the concentration of ores and minerals. At the Niagara Falls plant Cyanamid has manufactured cyanides for many years for the recovery of precious metals from dilute solutions. Flotation reagents are produced at Warners and Azusa for the concentration of nonferrous and the so-called nonmetallic minerals from their ores. Cyanamid also is the sales and technical representative for heavy-media separation processes, a gravity method of concentrating minerals and coal.

In 1930 American Cyanamid Co. negotiated three new acquisitions. The Lederle Antitoxin Laboratories in Pearl River, N. Y., and Davis & Geck, Inc., in Brooklyn, projected the Company into the allied fields of pharmaceuticals and sterile sutures; while the acquisition of Chemical Construction Co. offered services in the design and construction of heavy chemical plants.

The name of Lederle Antitoxin Laboratories later was changed to Lederle Laboratories, Inc., and in 1946 became the Lederle Laboratories Division of the parent company. Lederle was founded in 1906 by Dr. Ernst J. Lederle, formerly Health Commissioner of N. Y. City. At first the only item produced was diphtheria antitoxin, but during the next few years were added tetanus antitoxin, typhoid vaccine, and other bacterial vaccines. In addition, a line of veterinary products was being developed. In the latter part of 1943 new manufacturing facilities were acquired in St. Joseph, Mo., center of the hog-raising industry, and manufacture of products for prevention and treatment of hog cholera was transferred to this new plant.

Today Lederle produces more than 2,000 pharmaceutical and biological items

for human and veterinary use, including sulfa drugs, penicillin, vaccines and serums, vitamins, and a full line of diagnostics and laboratory reagents. Increased production has allowed Cyanamid's Lederle-Calco Drug Export Department to expand as well, sending salesmen into India and China, maintaining subsidiaries in Argentina, Mexico, Cuba, and Puerto Rico, and selling through foreign distributors. Among the newer pharmaceuticals and biologicals already in great demand abroad are Folvite folic acid and the sulfonamides, particularly sulfadiazine. Many of these products are manufactured in bulk by Calco, which distributes them to numerous pharmaceutical houses, including Lederle. Lederle packages and distributes them along with its own products.

The second unit acquired by Cyanamid in 1930, Davis & Geck, was organized in Brooklyn, in 1909, and manufactures more than 1,000 different kinds of sutures and suture-needle combinations for distribution through surgical supply houses. Basic materials include catgut, silk, stainless steel wires, horsehair, kangaroo tendons, nylon and other synthetic strands.

The third 1930 acquisition, Chemical Construction Co., was originally organized at Charlotte, N. C., in 1914. During the First World War, it had constructed sulfuric acid and U. S. Government nitric acid plants, and its subsequently developed acid recovery process was widely used by oil refineries. Reorganized as Chemical Construction Corp. and enlarged by the addition of Chemical Engineering Corp., which was acquired during the same period, Chemical Construction designs and builds plants for the heavy chemical industry. Many of these plants employ processes and equipment specially developed by Chemical Construction and controlled by numerous United States and foreign patents.

To operate Cyanamid's Canadian plants, North American Cyanamid, Ltd., a Canadian corporation, was organized as a subsidiary in 1934. The most recent acquisition of North American was the purchase in 1946 of the Welland Chemical Works at Port Robinson, Ont. Welland was built by, and operated under the supervision of, Chemical Construction Corp. and produced, during the war, a new type of highly explosive material for the Canadian Government. Today, as a subsidiary of N.A.C.L., it produces ammonium nitrate for fertilizer, nitric and sulfuric acids, dicyandiamide, and guanidine nitrate. In addition, it offers excellent opportunities for further Canadian expansion.

In the course of its industrial expansion over the years, Cyanamid believed that certain chemical processes might develop more logically if the Company joined forces with other companies. Hence, acting jointly with the Pittsburgh Plate Glass Co., it formed the Southern Alkali Corp. and the Southern Minerals Corp. It also owns jointly with International Paper Co., the Arizona Chemical Co.; and with the Texas Co., the Jefferson Chemical Co.

In its process of growth the Company also acquired scattered groups of research personnel. In 1937 expansion and consolidation of research efforts resulted in the establishment of the Stamford Research Laboratories at Stamford, Conn. With the exception of research on biological products and vitamins, which were continued at the Lederle Division, and research and development work on dyes, pigments, their intermediates, and synthetic pharmaceuticals done by the Calco Chemical Division, all research is centralized at Stamford. Work here is divided into the following divisions: the Chemical Research Laboratories, to provide new chemical products for evaluation in industrial or agricultural applications; the Technical Service & Development Laboratories, where applications of chemical products are stud[illegible] plastics, surface coatings, textiles, paper, rubber, leather, petroleum, water pu[illegible] tion, sugar refining, and for agricultural uses as fertilizers, insecticides, fung[illegible] weed killers, and defoliants; the Chemical Engineering & Pilot Plant Labor[illegible]

where manufacturing processes are developed; the Physics Research & Testing Laboratories, where physical-testing equipment is consolidated, new instrumental tools of value in research or plant control developed, and research in physics or physical chemistry conducted on many phases of the Company's activities; the Chemotherapy Research Laboratories, specializing in synthetic pharmaceuticals from initial synthesis through screening tests and toxicity studies (the Chemotherapy Laboratories correlate their work with that of Lederle, which pursues all clinical studies, and Calco, which supplies compounds for screening and develops processes for bulk production of synthetic drugs); the Metallurgical Research & Mineral Dressing Laboratories, where applications of chemicals to mining are worked out and basic mineral beneficiation processes are serviced on a world-wide basis; and the Basic Nitrogen Research Laboratories, responsible for improving present processes and developing new ones for the production of cyanamide, cyanide, and their derivatives. Along with this expansion of research at Stamford, the research and development groups at Lederle and Calco were correspondingly increased.

Thus, while the major growth in the early days of Cyanamid was often by the acquisition of other companies, more recently it has been largely by growth from within—by launching or expanding the production of new research products. The major Cyanamid research developments in the past ten years now in volume production are melamine, laminating adhesives, and ion-exchange resins; sulfa drugs, new vaccines, and synthetic folic acid; wetting agents; acrylonit 'le and other rubber chemicals; lubricating oil additives and petroleum-cracking catalysts; defoliants and plant hormones; vat dyes; and mineral-dressing reagents.

American Cyanamid Co. officers are: president, W. B. Bell; vice-presidents, R. M. Banks, H. P. Eastman, F. M. Fargo, Jr., R. C. Gaugler, J. O. Hammitt, W. G. Malcolm, G. R. Martin, S. C. Moody, R. C. Swain, and K. C. Towe; assistants to the president, E. J. Dempsey, R. B. Fiske, and H. R. Huston; treasurer, L. C. Perkinson; assistant treasurers, J. A. Oates, C. B. E. Rosane, and A. B. Savage; secretary, W. P. Sturtevant; assistant secretaries, R. B. Fiske and R. S. Kyle.

AMERICAN DYEWOOD COMPANY was incorporated in 1904, that year being the date of the merger of the New York & Boston Dyewood Co. of N. Y. City and the Sharpless Dyewood & Extract Co. of Philadelphia. The Company's business, however, traces back in direct succession to William Patridge & Sons, which started operations in 1798, and therefore celebrates its 150th anniversary in 1948.

The Company has always been best known for its dyestuffs and tanning extracts, chiefly dyewood extracts manufactured from stick logwood, fustic, brazilwood, osage orange, quercitron bark, quebracho, mimosa, etc. More recently, through its wholly owned subsidiary, the New York Color & Chemical Co., the Company has engaged in the production of coal-tar dyes, synthetic color lakes, synthetic tanning materials, and chemical specialties.

The first board of directors was composed of: Joseph C. Baldwin, Thomas Scattergood, Joseph C. Stevens, John W. Pepper, Joseph C. Baldwin, Jr., Percival Thomas, George S. Hutton, J. Henry Scattergood, Thomas H. Austin, William M. Baldwin, William W. Macfarlane, DeWitt Clinton Jones, Jr., J. Herbert Ogden, T. Chalkley Palmer, and Charles I. Thayer. It elected Pepper, president; Baldwin, [illegible] vice-president; Thomas, 2d vice-president; Hutton, treasurer; Austin, assistant treasurer; J. H. Scattergood, secretary; and Jones, assistant secretary.

The Company's extraction plant at Chester, Pa., on the Delaware River, has

wharfage facilities for berthing steamers which discharge various stick dyewoods that are transported to the chipping machinery by power cranes and a narrow-gauge railroad. These materials are extracted in open leaches, autoclaves, etc., and the extracts concentrated in modern evaporators, a large portion being dried in a spray tower, erected in 1944, where the moisture content is reduced to less than 5%. A substantial portion of the extracts is sold in liquid form of unvarying uniformity; for certain industries, in solid slabs. The products of this factory are chiefly used for dyeing and tanning in the leather, textile, fur-dressing, woodstaining, and lake-making industries.

The factory operated by the New York Color & Chemical Co. Division is at Belleville, N. J., on the Passaic River, covering about 10 acres. It has been constantly expanded during the last 25 years and its products are used variously by textile manufacturers, tanners, and finishers of leather, printing-ink manufacturers, paper and pulp manufacturers, and in many miscellaneous lines. Here, also, are located the well-staffed research laboratories.

The board of directors elected in Feb. 1947 is composed of P. R. Mackinney, J. Henry Scattergood, C. S. Thomson, F. C. Fuller, E. W. Picker, H. R. Tisdale, B. R. Neice, W. Palmer, and R. H. Underdown. The present officers are Mackinney, president; Tisdale, vice-president; Fuller, secretary; F. B. Grimshaw, assistant secretary; Picker, treasurer; and Fuller, assistant treasurer. The Company's executive office is located at 22 E. 40th St., N. Y. City, with branch offices and warehouses in the principal cities of the United States and Canada.

AMERICAN HOME PRODUCTS CORPORATION was organized Feb. 4, 1926, in Delaware, by John F. Murray, advertising agency; A. H. Diebold and W. E. Weiss, Sterling Products (Inc.); Stanley P. Jadwin, wholesale druggist; William H. Kirn and W. D. Rowles, Parke, Davis & Co. These six men had owned and operated the Wyeth Chemical Co. and its subsidiaries, manufacturers of proprietary medicines since 1909, as an independent enterprise. Thus the sponsors had begun some 17 years before to lay the foundation for this new company. At their first meeting, Feb. 5, the directors elected Kirn, president; Jadwin, vice-president; and Murray, secretary and treasurer; and established the Company office at 578 Madison Ave., N. Y. City.

American Home Products brought together the Wyeth Chemical Co. and its subsidiaries, the DeShell Laboratories, and the partnership of Edward Wesley & Co. All the products of these companies were nationally advertised and distributed proprietary remedies, some of them having been on the market for over 30 years, and bearing such well-known brand names as Petrolagar, Wyeth's Sage and Sulphur, Hill's Cascara Bromide Quinine, St. Jacob's Oil, Rowles Mentho-Sulphur, Freezone, Dioxol, Heet, and Jad's Salts.

Early in 1927, after a first year's net sales of nearly $4,500,000, the Corporation established a policy of expansion and diversification through acquisition of additional widely distributed products. The first acquisition, May 1, 1927, was of A. S. Boyle Co., whose principal product was the widely advertised "Old English" brand of floor wax. Boyle was the outgrowth of a small partnership dating back to 1830. By this addition, American Home Products laid the foundation for its Household Products Division, the first breakaway from a strictly proprietary drug business.

This acquisition crystallized two other basic policies. One was to retain the acquired subsidiary's management. The second was that of "promotion within the ranks." Acquisition of the Boyle Co. provides an outstanding ex... for Walter Silbersack, its general manager, having joined in 1923 as adve... and merchandising manager, was retained in his executive position and ...

director in the reorganized household products unit. Silbersack grew with the development of the parent company and today (1947) is its president and general manager.

Aug. 31, 1927, the Oxzyn Co., one of the largest domestic manufacturers of cosmetics, was acquired, opening another field in the Corporation's policy of diversified expansion. The International Chemical Co., Ltd., of London, manufacturing proprietary medicines under the trade-mark Bisurated Magnesia, was purchased Sept. 22, 1927, with a factory in London and an experienced distribution organization for overseas trade. A third addition in 1927 was the BiSoDol Co., manufacturers of an antacid digestant.

During 1928-29 the Corporation acquired other well-known businesses. On July 12, 1928, the Kolynos Co. was added. This company, organized in 1908, manufactured Kolynos dental cream, and brought with it two fully owned subsidiaries, the Kolynos Sales Co. and Kolynos, Inc., which conducted the European business. Oct. 30, 1929, American Home Products acquired several proprietary drug companies: the Manhattan Medicine Co., manufacturers of Atwood's Bitters; the Ripans Chemical Co., manufacturers of Ripan's Tabules since 1892; and the Bovinine Co., organized in 1892, manufacturers of medicinal and pharmaceutical preparations, including Bovinine, a medicated beef juice marketed since 1885.

Thus by the end of its first four years it had not only proprietary drugs, but also household products, cosmetics, and dentifrices, and was now obtaining a wide distribution of its products throughout the United States, England, Continental Europe, and South America. Net sales for 1929 were $13,600,000, an increase of over 200% in three years.

The success of the Corporation during this period paralleled the rise of the proprietary drug industry throughout the world, a development due to at least seven major factors: (a) Proprietary goods of recognized value were maintaining a growing market in the United States and abroad, through established retail drug units. (b) This market had been steadily increased by liberal advertising appropriations. (c) Patented and trade-marked products, thus popularized by advertising, continued in demand. (d) Unit prices of goods were so low that the business depression was having only a minimum effect on both sales and profits. (e) Sales turnover had been so rapid that fluctuations in raw material commodity prices were to date of negligible influence on operating costs. (f) The proprietary industry was consolidating operations in large units of great financial stability and sufficient resources to insure economical manufacturing and aggressive marketing programs. (g) More and more, maximum efficiency was being obtained by means of scientific methods based on extensive research.

1930 witnessed several corporate changes. The bylaws were amended, increasing the directors to 12 and corporate officers from four to six. President William H. Kirn was elected chairman and T. E. Caruso, president and general manager. Here again was promotion from the ranks, for Caruso had been sales manager and assistant general manager of Kolynos at the time of its acquisition. One important acquisition was made during 1930, that of Van Ess Laboratories, manufacturers of toilet preparations for the scalp. Van Ess owned the capital stock of Anacin Chemical Co., which had exclusive rights to the anodyne tablet of nondepressing coal-tar products, destined to become the successful competitor of aspirin and other headache and pain remedies.

During the next four years the Corporation made only one acquisition, but doubtedly one of its most important, John Wyeth & Bro., founded in 1860 and ne time considered the second largest pharmaceutical house in the country. m its inception, research in pharmacology had been a prominent activity of

Wyeth and its promotional policy was strongly ethical. Its principal products were Wyeth's collyrium, Wyeth's effervescent sodium phosphate, Wyeth's lithia tablets, Wyeth's elixirs, suppositories, and an extensive line of well-known pharmaceuticals. This purchase, completed June 24, 1931, marked the expansion into the field of pharmaceutical and ethical drugs.

Early in 1935 the Corporation entered a new period of development. During the previous year chairman Kirn had retired from active business. At the same time president Caruso resigned and Harry S. Howard, formerly of DeShell Laboratories, was made general manager and on Jan. 24, 1935, elected president. Three months later Alvin G. Brush, president of Affiliated Products, Inc., was elected chairman of American Home Products. A man with a keen analytical mind, especially in the field of corporate finance, Brush brought a new dominant spirit into the organization.

Under the new leadership the Corporation commenced a program of expansion and diversification in six major classifications: ethical drug preparations; food products; publicly advertised medicinal, pharmaceutical, and dentifrice preparations; household products; cosmetic and toilet preparations; and chemicals, organic colors and pigments, dyestuffs and intermediates.

In the ethical drug field, the first major development during 1936-46 was the acquisition of S.M.A. Corp., July 23, 1938, whose business consisted of milk food products and vitamin products. Besides carotene, SMACO vitamin preparations, and powdered milks, the most important was S.M.A., a baby food derived from tuberculin-tested cow's milk in which the fat is replaced by animal and vegetable fats. Through its research laboratories, the company had made significant nutritional advances in vitamin A test diets, rachitogenic diets, crystalline vitamins, concentrates exhibiting biotin (vitamin H) activity, and such biochemicals as ethyl nicotinate, phytin, glutamine, galactose, and others.

American Home Products added a general line of vitamin products through the International Vitamin Corp. (Oct. 22, 1941) and the Miller Wholesale Drug Co. of Cleveland and its subsidiaries (Dec. 1, 1941). International Vitamin manufactured vitamin products, doing also a large business in bulk tablets, capsules, and special mixtures for various pharmaceutical manufacturers, drug jobbers, and chain drugstores. Miller manufactured and sold vitamins, pharmaceutical and medicinal products, and owned equipment for producing gelatin capsules.

The biological field was entered through the acquisition of Reichel Laboratories (Dec. 1, 1942), and the Gilliland Laboratories, Inc. (July 15, 1943). Reichel produced blood plasma, typhus vaccines and serums, and later became an important manufacturer of penicillin. Gilliland made biological-pharmaceutical products, including antitoxins, serums, vaccines, and redistilled water for intravenous use. Coverage of the ethical drug field was further broadened by the acquisition (Mar. 1, 1943) of Ayerst, McKenna & Harrison, Ltd., of Canada and its U. S. subsidiary, engaged in the manufacture and sale of hormone, biological, vitamin, and pharmaceutical products.

Drug operations were extended to the veterinary field through Research Products Corp. (Aug. 1, 1944), manufacturers of veterinary pharmaceuticals; and Ford Dodge Serum Co. (Apr. 3, 1945), one of the largest manufacturers and distributors of biological and glandular products for the treatment of animals.

In the Household Products Division, additions during the 10-year period included the following: the business under the trade-mark Grip, covering cements, glues, mucilage, and other adhesives, from the Consolidated Chemical Co. (Dec. 13, 1935); Three-in-One Oil Co. (Jan. 2, 1936); Wizard Co. and its subsidiaries, manufacturers of sweeping compounds, polishing and cleaning preparations, mop

furniture, and stove polishes, and insecticides (Apr. 16, 1937); Black Flag Co., manufacturers of Black Flag insecticide, insect sprays, powders, and disinfectants (Sept. 11, 1939); Antrol Laboratories, Inc., manufacturers of insecticides (Feb. 12, 1940); Dri-Brite, Inc., liquid and paste waxes, polishes, and cleaners (Nov. 14, 1940); Cardinal Laboratories, manufacturers of the Rite-Way household waxes, cleaners, polishers, and mops (Dec. 11, 1940); Keefe Chemical Co., manufacturers of the Silver Label germicides (Apr. 28, 1941); Salem Chemical & Supply Co., polishes, disinfectants, germicides, and lubricating oils (June 4, 1941); Pla-Steele Co., manufacturers of a plastic compound used as a solder (July 17, 1941); Baldwin Laboratories, Inc., various insecticides and cattle sprays (Aug. 7, 1941); Kant Rust Products Corp., manufacturers of the Kant-Rust automobile polishes and cleaners, lubricants and gum solvents (Nov. 1, 1941); Dexta Co., aluminum cleaners and polishes (Feb. 6, 1942); Wells & Richardson Co., Inc., of Vermont, makers of Diamond dyes (Dec. 1, 1943); and Prescott Paint Co., specializing in show-card colors and water-thinned paste paints.

A significant trend in the Corporation's expansion program during 1935-45 was the creation and development of its Food Division. It first acquired, May 23, 1939, the business of Harold H. Clapp, Inc., manufacturers of baby foods. On May 14, 1943, it bought G. Washington Coffee Refining Co., makers of soluble powdered coffee, broth powder, and bouillon. Further expansion occurred Mar. 1, 1944, with the acquisition of P. Duff & Sons, Inc., prepared baking mixes. In 1946 were added Chef Boy-Ar-Dee Quality Foods, Inc., manufacturers and distributors of spaghetti goods; Joseph Burnett Co., producers and distributors of flavoring extracts and food colors.

Likewise in cosmetics, the Corporation made important expansions during the decade. On Jan. 3, 1936, Mystic Laboratories, Inc., manufacturers of hand creams, lotions, and cleansing creams, was acquired; three months later, Affiliated Products, Inc., and its subsidiaries, manufacturers of diversified cosmetic preparations. The last addition to the Cosmetic Division was the purchase of the Vida-Ray brand of cosmetics, Mar. 10, 1943.

The Division of Organic Colors and Chemicals was started Nov. 30, 1942, when the Corporation bought Harmon Color Works, Inc., producers of organic chemicals, including pigments and intermediates. Harmon's largest single customer prior to World War II was the automobile industry. Following acquisition it manufactured substantial quantities of quinacrine hydrochloride (antimalarial drug) and sulfathiazole, but after the war these drugs were discontinued and full-scale production of colors was resumed. Two years later purchase was made of the Marietta Dyestuffs Co., makers of dyestuffs and drug intermediates, but sold July 1, 1946 to American Cyanamid Co.

This program of expansion and diversification, coupled with development of new products within the Corporation, has resulted in annual sales in 1945 of $116,000,000. Substantially all the products sold by the Corporation are manufactured in its own plants, a wide variety of raw and semimanufactured materials being purchased from many sources. Most of the sales are made in packaged form under the Corporation's own trade-marks and brand names. Approximately 16% of 1945 consolidated sales comprised exports and sales of subsidiaries and branches outside the United States.

Another important development during the past decade has been the emphasis placed on research and new products. The Corporation maintains 31 laboratories engaged in research and control work on pharmaceuticals, biologicals, antibiotics, nutritionals, hormones, organic chemistry, cosmetics, medical science, allergens, foods, dentifrices, insecticides, detergents, waxes, oils, polishes, colors, color inter-

mediates, paints, and production machinery. These activities have been substantially increased during the past five years, with expenditures for research in 1945 nearly double those of 1944 and nearly four times those of 1941. In 1945 the sales of new products developed in these laboratories during the preceding 10-year period totaled in excess of $33,000,000, while new products developed during 1945 provided a sales volume of approximately $3,500,000.

During 1935-46 management continued under the direction of Alvin G. Brush. There have been, however, changes in the personnel of the officers and directors. In Sept. 1943, Harry S. Howard, president since 1935, was made president of Wyeth, Inc., a new subsidiary under which the various ethical drug units were consolidated. Knox Ide, executive vice-president, was elected to succeed Howard as president of American Home Products. Two years later, Ide resigned and was succeeded by Walter Silbersack.

In two decades American Home Products has grown from a business represented by annual sales of $4,500,000 to one of over $116,000,000. Its personnel has increased from fewer than 250 to more than 12,500. In the United States and Canada are 31 laboratories, 38 plants, 38 sales headquarters, and 55 warehouses; more than 20 foreign subsidiaries are located in England, South Africa, Argentina, Australia, New Zealand, Mexico, Eire, and India. The Corporation has paid monthly dividends since 1926, the year of its organization. Throughout its history it has enjoyed splendid personnel relations with no labor disturbances.

AMERICAN MAIZE-PRODUCTS COMPANY had its inception in 1906 when a group of men headed by Daniel Scully and Philip Saenger formed the Western Glucose Co. to manufacture products from a process now known as the wet corn-milling process. They contributed capital through the purchase of preferred stock and constructed a manufacturing plant which could grind about 8,000 bushels of corn per day.

In 1908 the Royal Baking Powder Co., then headed by F. J. Boselly, purchased the Western Glucose Co. and changed its name to the American Maize-Products Co. Boselly became its president. At the time Royal Baking Powder's interest in the project was chiefly to obtain a plant which could supply it with one of the important ingredients of baking powder, i.e., cornstarch.

In 1910 American Maize-Products employed R. E. Daly, previously plant superintendent of the Chicago Starch Co., and through his efforts and the Company's policy of plowing back earnings into the business, the capacity of its corn-grinding plant was increased to 30,000 bushels daily by 1936.

On Boselly's death, William S. Champ was made president and served in that capacity until Aug. 1919, when Cornelius D. Edinburg of the Royal Baking Powder Co., who had joined American Maize-Products in 1910, succeeded him. Largely through Edinburg's efforts, the Company developed outlets for its products that required an extension of manufacturing facilities. In 1925 the Company entered the dextrin business and ever since has been developing new types of dextrins.

Royal Baking Powder Co. and Fleischmann Co. merged in 1929 into Standard Brands, Inc., and the former company sold its interest in American Maize-Products to its stockholders. Since that time American Maize-Products has been an independent company.

It was in 1929 that the Company entered the field of lactic acid and lactate produced from corn. Donald K. David became president, Jan. 1, 1932. He h managed the Royal Baking Powder Co. as executive vice-president, from 1927 and had acted as advisor to Edinburg since 1927. Under his guidance the Compa expanded, modernized the plant, and developed many new products. Starch sp

cialties were becoming more and more important. Also, the Company at this time began to pioneer in purified protein products from corn, becoming the first to produce dried corn sirup products in 1935.

David resigned to become Dean of the Harvard School of Business Administration and was succeeded in 1942 by Theodore Sander, Jr., vice-president. Sander led the Company through trying war years when a record volume of business was produced and plant expansion was continued until capacity now in excess of 40,000 bushels daily was reached. In 1942 the Company introduced a new starch from domestic corn, similar to or better than the best type of imported tapioca starches. The following year steepwater solids for production of penicillin were developed.

The Company recently completed a new research laboratory building; a modern plant for chemical modification of starch; and an extensive plant-wide program aimed at lower processing costs and higher yields.

AMERICAN POTASH & CHEMICAL CORPORATION goes back to when John W. Searles, prospector and Indian fighter, in 1862 rediscovered the California lake which now bears his name. Searles Lake was first sighted by a band of thirsty gold seekers in 1849. Great was their disappointment to find that what looked like deep blue water was a mirage—that the surface was actually only an expanse of dried salt. Still thirsty and a little more weary, they pushed on, leaving behind the world's greatest commercial deposit of diversified chemicals. This "lake" of chemicals is circular with an area approximately 12 miles square with an average depth of 70 ft. The whole depth is made up of salt crystals, the top 15 ft. being sodium chloride. The interstices of the crystals hold the brine, the level varying. The deposit is unlike most other potash deposits because it results from the evaporation of solutions from the leaching of volcanic mountains and not from sea water evaporation.

Searles set up a small plant to reclaim semirefined borax which he carted 200 miles to Los Angeles in large high-wheeled wagons drawn by a string of mules. It sold for $700 a ton. The plant was operated intermittently 33 years, to be abandoned in 1895 when other easily extracted borax deposits were discovered. For 10 years Searles Lake lay undisturbed in the desert.

Another prospector found trona in 1905. The name "trona" is of Egyptian origin and refers to the double salt of normal and acid carbonate, $Na_2CO_3NaHCO_3.2H_2O$. This discovery led to exploratory work in 1912 and it was established that the most important commercial values of Searles Lake were in the brine rather than the salt crystals. The American Trona Corp. was formed and a plant constructed in 1914 to remove potash and other chemicals from the brine. This development was opportune, Germany, chief supplier of potash, being at war, but the task of converting brine into commercial potash was extremely difficult. An entirely new process was required; many natural disadvantages incident to the location and the climate had to be overcome; modern transportation facilities did not exist; water was not easily available; housing for employees was lacking—all had to be supplied in the remote desert. Scientific skill and persistence won and the first shipment of potash was made Oct. 1916, only a few months before we were involved in the war. Research continued and the production of borax was begun commercially in 1919. The year following, the Company produced 9,629 tons of muriate of potash and 4,643 tons of borax.

By 1926 annual output had increased to nearly 32,000 tons of muriate of potash [illegible] 15,500 tons of borax. In the summer of that year the American Potash & [illegible] Corp. was organized to succeed the American Trona Corp. The new [illegible] immediately enlarged and completely rebuilt the plant without stop-

ping production. Production facilities more than doubled in 1927 and the manufacture of boric acid was undertaken. In 1930 the output of muriate of potash exceeded 93,800 tons and that of borax, 53,000 tons.

The second major expansion began in 1929 and when completed in 1934 production capacity was again nearly doubled. Facilities were also provided for the manufacture of Pyrobor (dehydrated borax), refined muriate of potash, and the recovery of sodium carbonate and sulfate. The next eight years witnessed a number of secondary operations relating to the conversion of primary products and the expansion of improvements in all existing processes. Crude lithium phosphate recovery was started in 1938 and production of sulfate of potash, in 1939. A bromine-recovery plant was completed in 1940 and the manufacture of U.S.P. bromides undertaken in 1941. Through process alterations the output of sodium carbonate and sodium sulfate was increased substantially. Production attained an all-time high in 1946: potash, 212,000 tons; borax, 102,148 tons; soda ash, 82,266 tons; salt cake, 139,686 tons; miscellaneous, 1,227 tons; total, 541,327 tons.

These figures should be exceeded, for research continues and plant expansion will keep pace. A new power plant, increasing the installed electrical generating capacity from 16,000 to 31,000 kw., is expected to be completed in the summer of 1948. A new $5,000,000 plant to process brine from a previously undeveloped deposit situated below that from which the brine is now drawn, will also be completed in 1948 and should produce an additional 60,000 tons of soda ash and 30,000 tons of borax annually. The research laboratory has been enlarged, its program being intensified towards diversification, particularly through manufacture of derivatives of the chemicals in Searles Lake brines, and improved plant process.

A remote desert environment requires more than plant equipment and process knowledge, and employees play a vital part. The modern village of Trona, which grew with the plant, is maintained exclusively for Company employees and their families, with modern homes designed and built for comfort in the desert available at low rentals. To accommodate single persons, the Company has provided attractively furnished quarters, with complete service. Necessary facilities for comfortable living are operated for Trona employees on a profit-rebating system. Food market, stores for drugs, clothing and hardware are all centrally located, as are the motion picture theatre, barber shop, poolroom, post office, telephone and telegraph facilities, bus and railroad depots, and a public library. There are restaurant accommodations, churches for the various religious denominations, and an excellent public school system providing education for over 600 students through high-school grades. The school is supported by taxes, a large percentage of which is contributed by the Company. A modern, well-equipped hospital attends the surgical and dental needs of the community, and varied recreational facilities are provided for children and grownups.

AMERICAN RESINOUS CHEMICALS CORPORATION took shape one evening in 1940, when William Abramowitz told Saul Palais his dream of a research organization to develop chemical processes and license them. The motivating power was to be distribution of the profits among the research men instrumental in building the company.

Palais had left Harvard in 1920 to found the Bay State Chemical Co. to manufacture leather finishes in Salem and Peabody, then the heart of the United States leather industry. He set himself to finding what the industry lacked developing a product to fit the need. He early realized the possibilities of na latex as an ingredient of leather finishes, which gave the infant company a un flexible finish. Then came a successful finish for split leather, previousl

undesirable by-product, followed by the first lacquer coatings for split leathers. In the 1930's Bay State opened plants in Newark and Chicago. In 1937 it acquired the Leather Finish Department of the Carpenter Morton Paint Co.; in 1942, the Keiner Corp., one of the oldest names in leather finishes; and in 1947, the C. L. Hauthaway Co., specializing in adhesives since 1852.

In 1940 Palais offered to finance a research organization to be called Industrial Inventions Co. A back room of Bay State's Newark plant was given to this new organization where a little laboratory was set up. Abramowitz hired Joe Klaber, a recent M.I.T. graduate, as an assistant, and laid out a program which included the synthesis of nicotinic acid and vitamin B_6, catalytic oxidation of fatty acids to dibasic acids, an edible synthetic cream, and preparation of resins by emulsion polymerization of monomers. Palais offered to be the first licensee if the new company could develop an acrylic emulsion for use with leather finishes.

Bay State about this time acquired the Keiner Corp. which possessed a process for making syntans. The product was occasionally good, the process generally unreliable. Ashworth Stull, later vice-president in charge of research of American Resinous Chemicals, joined the group to perfect the syntan process. Dr. Austin Pomerantz was engaged to work in fine organic chemistry and a young chemical engineer, Sidney Baum, then working for his doctorate at Columbia, offered to work nights and week ends on catalytic oxidation.

After about six months an acrylic emulsion was developed that seemed satisfactory to the local tanneries and the process was sent to the Bay State Peabody plant, where Jack Lichman, later vice-president in charge of production, was given the task of producing the emulsion commercially.

Then came really hectic days. After several months of working around the clock, a satisfactory commercial process was evolved, but sales were heartbreakingly slow. Industry in general was at a low ebb. The first barrel order was the occasion for a jubilant celebration. Soon there came a 10-barrel order and one fateful day, an order for a carload. This was wonderful except that it took four hours to make the emulsion, the equipment could make only one barrel at a time, and immediate shipment of the carload was requested. Lichman and Abramowitz completed the order in a week and further orders for monthly carload shipments followed.

In the meantime Stull had developed a smoothly operating syntan process for the Keiner Corp.; Dr. Pomerantz had obtained nicotinic acid in low yields; Baum had split oleic acid in half with a high yield of pelargonic acid, but azelaic acid could be found only as maleic and succinic. The synthetic cream was quite acceptable in coffee but it turned tea to a beautiful nauseous green.

The research program devoured money rapidly and the original advance from Palais had been used up twice over. Troubles seemed to multiply at once. Personnel changes left only Stull, Lichman, and Abramowitz. It was decided to move the laboratory to Peabody and to concentrate on emulsions. A corner of the Bay State plant was rented and Industrial Inventions Co. was incorporated as the American Resinous Chemicals Corp.

Its efforts were concentrated on resin emulsions, a hitherto relatively neglected method of utilizing resins. Because emulsions utilized water as an inexpensive, nonflammable, nontoxic vehicle for resins, new fields for uses in adhesives, coatings, sizings, and saturants were opened. Vinyl, alkyd, maleic, ester gum, and similar emulsions were developed to supplement the acrylic emulsions. Vinyl copolymer resins were just appearing on the market and with these as a base, new types of otective coatings were offered to industry. After Pearl Harbor, huge quantities emulsions were required to extend and replace latex. The Company was th requests for emulsions to replace latex for uses varying from shoe

adhesives to paper saturants and surgical bandages. The war program tremendously accelerated growth and activities crystallized into the three systems by which synthetic resins are utilized: hot melts, solutions, and emulsions. In 1942 Dr. Baum returned to the group. In a few months he had streamlined production. Before the year was over another M.I.T. graduate, I. Kusintz, was hired to direct engineering and Dr. Baum returned to the laboratory to direct the Polymer Division. By 1944 he developed the processes of copolymerization in emulsion form sufficiently to warrant construction of a polymerization plant, thus completing one of the first projects of the research begun four years before. It was decided to specialize in individual copolymers for specific industrial purposes rather than to offer one or two resins for broad utilization. The Polymer department became the fastest growing and its products spread into the paper, leather, paint, printing ink, textile, adhesive, and plastics fields. At the end of the war Dr. Baum was asked by the Government to investigate the German polymerization plants.

During the war the Company produced a number of outstanding products, including a corrosion-resistant dielectric coating for metal batteries; emulsions for making plastic foam for buoyancy cells for the Normandy invasion fleet; vehicles for phosphorescent marking paints; adhesives for cohesive bandages; and Norepol synthetic rubber from soybean oil. By the end of the war, 90% of production was for direct military uses. V-J week brought cancellation of 80% of its business. Here the policy of continued research proved itself and soon products developed from this program found wide-scale peacetime acceptance. Sales for 1946 were the largest in the history of the Company and sales for 1947 were almost double.

The percentage of sales income allocated to research and development is one of the highest in the country. A large technical staff maintains close contact with consumers and producers and with current developments in resins and plastics. Long-term projects of the Research Department include polymerization; monomer, and plasticizer synthesis; compounding of resins, plasticizers, and fillers; and fundamental study of the physical chemistry of high-molecular weight compounds.

To maintain business stability, the Company has endeavored to manufacture diversified products which currently include: synthetic resins for paints, varnish, leather, paper, textiles, and adhesives; organosols and plastisols for coatings; natural and synthetic latex compounds and tackifiers for adhesives, saturants, and coatings; and specialty wood glues, hot melts, and protective coatings for various industrial purposes.

American Resinous Chemicals Corp. and the associated companies of the Palais Industries have six plants in the United States, one in Canada, two in Europe, and one in South America.

AMERICAN VISCOSE CORPORATION was the first maker of rayon on a commercial basis in the United States. Today it is the largest producer in this country, manufacturing each year approximately one-third of the total produced.

The successful spinning of viscose rayon yarn was first achieved in England by the century-old textile firm of Samuel Courtauld & Co., Ltd., which started production at its plant in Coventry, England, Nov. 1905. After three years of hard work the company had overcome the most difficult of the initial problems and saw its new man-made fiber well on the road to assured success. The yarn was making good progress in England and it was decided to export to the United States.

Samuel A. Salvage, a New York yarn merchant, was appointed in 1908 to handle sales in this country and he started immediately to develop markets for the new product. It was an uphill struggle, for the textile industries were hesitant to try out the new fiber. Salvage persevered, however, and his persistence was re

warded. He began to meet with encouraging success. Manufacturers of braid, millinery, embroidery, ribbons, and trimmings found the new yarn suitable for their use and commenced to buy it in sizable amounts. One early, out-of-the-way use in the United States was in the manufacture of prayer rugs.

Encouraged by this progress, Courtauld's purchased the United States licensee patents for the manufacture of viscose rayon in June 1909, and in November Henry G. Tetley, one of Courtauld's directors, and James Clayton, chief engineer, came to the United States and purchased a site for a rayon-producing plant at Marcus Hook, near Chester, Pa. A new American company, American Viscose Co., was registered on Mar. 15, 1910, under the laws of Pennsylvania. Shares were paid for in cash by the parent concern in England, and the United States patent rights were transferred to the American Viscose Co. in exchange for further shares. George H. Rushbrook, secretary of Courtauld's, and for many years its legal advisor, was appointed president, and Francis S. Younghusband, an American who had enjoyed a long association with Courtauld's, was appointed treasurer.

There followed 18 months of activity that started the rayon industry in the United States. By Oct. 1911 the Marcus Hook plant was in commercial production. During the final months of that year it produced 362,544 lb. of rayon. All this was sold without difficulty, due to the market development work done in the preceding three years.

During 1911 Dr. Charles A. Ernst, a chemist associated with earlier attempts to make rayon in the United States, studied the rayon-producing methods at Coventry, and he was appointed general manager of the Company in Aug. 1911. He was greatly aided by Henry Johnson, manager of the Coventry plant, who made numerous visits to the United States to give the benefit of his long experience. When the Marcus Hook plant started, its personnel totaled about 600 people. A number of rayon technicians originally employed at Coventry came over to work for American Viscose and rendered distinguished service in overcoming many problems of the early days and getting the United States rayon industry off to a good start. Salvage, who had now become the United States agent for Samuel Courtauld & Co. exclusively, sold the Marcus Hook production. At the time, the United States was consuming annually about 2,115,000 lb. of rayon yarn, of which more than 1,800,000 lb. were imported.

By 1912 large quantities of men's socks were being knitted from viscose rayon yarn in the United States, and it was believed that an important market could be developed in women's hosiery. Special attention therefore was given to the hosiery trade and other manufacturers of knitted fabrics with the result that by 1915 about 70% of all rayon consumed in the United States was being used by knitting mills. At the same time weavers were beginning to experiment with the new yarn in dress and other fabrics.

The Marcus Hook plant was now employing about 2,500 and the output in 1916 was 5,778,000 lb. Demand was constantly expanding and about 2,500,000 lb. had to be imported each year. Because of these conditions, Courtaulds, Ltd., on the recommendation of Salvage, decided in 1916 to build a second plant. At the same time Salvage was elected vice-president of the Company. The new plant was located at Roanoke, Va., and started commercial production in Oct. 1917. As the demand for rayon continued to expand, a third plant was decided upon in 1920, located at Lewistown, Pa., which commenced operations in Aug. 1921. In Nov. 1922 the Company bought a small plant at Nitro, W. Va., used during World War I [illegible] the manufacture of guncotton, which was converted to make cotton linters pulp [illegible] company's three plants.

[illegible] plants were built during the 1920's, a decade that witnessed a very

great expansion of rayon production in the United States as other companies entered the field. These plants were at Parkersburg, W. Va., and Meadville, Pa. The Parkersburg plant, which started in 1927, was built for viscose rayon, the Meadville, completed in 1930, was designed to produce acetate rayon, the second most important type of rayon used in this country. (A third type, cuprammonium rayon, is produced in such small quantities that it represents less than 5% of the country's total output.) Acetate rayon is particularly suitable for high-quality satins, taffetas, and other fabrics in which softness and luxurious draping qualities are required. It is used with viscose rayon to achieve crepes and to obtain cross-dye effects.

A great deal of progress was made during the 1920's in improving the quality and versatility of rayon. Tensile strength had been increased, finer filaments had been spun, and more filaments in a given weight of yarn resulted in softer, more pliable yarns and fabrics. Production in the United States in 1930 totaled 128,-000,000 lb. as compared with 10,000,000 in 1920. By 1924 rayon had won a distinct place for itself in the textile world, and the old term "artificial silk" was no longer adequate. A new name was needed and a committee, headed by S. A. Salvage, selected the name "rayon." In the following year Salvage was elected to succeed Dr. Charles A. Ernst as president of the Company.

The early use of rayon was limited to bright, rather showy fabrics because of its high luster. In 1926 American Viscose produced the first commercial dull rayon yarn in this country and immediately new fields were open to rayon. Several methods of producing dull rayon are now used and the result is a variety of degrees of luster ranging from satins to broadcloths and georgettes. By 1927 yarn had been steadily improved until it could pass perfectly through all machine processes and produce fabrics with durability as well as beauty. At that point it was discovered that viscose rayon could be given a high twist and made into crepe yarns. In the same year high-tenacity or high-strength rayon yarns were introduced, largely due to a special method of spinning developed by the American Viscose Corp.

With rayon fabrics an accepted member of the family of textiles, there came a need for a method of assisting the consumer, retailer, and garment manufacturer to predict their serviceability. The American Viscose Corp. "Crown" Tested Plan was created to meet this need. Under this plan "Crown" Tested identification is awarded to fabrics containing "Crown" rayon, after they have passed the "Crown" tests for serviceability. These generally include fabric strength, shrinkage, color fastness, and washability, depending on the use to which the fabric is to be put. According to a wealth of evidence, the "Crown" Tested Plan has been an important factor in improving the quality of rayon fabrics and in maintaining their good reputation.

A major development of the 1930's, in which American Viscose played an important part, was the development of rayon staple. This product consists of short rayon fibers, usually ranging from one to eight inches in length, which in many respects are comparable to the natural fibers, cotton, wool, and flax. These fibers are spun into "spun rayon" yarn on regular cotton, woolen, worsted, and spun silk equipment, and the yarn is then woven or knitted into "spun rayon" fabrics. Until rayon was manufactured in these shorter lengths it could not be used for a whole range of woolen and worsted-type fabrics: coverts, gabardines, flannels, and tweeds; and in rugs, blankets, towels, and sheets. A number of textile mills had commenced during the 1920's to produce spun rayon yarns and fabrics, using imported rayon staple, and in 1935 American Viscose started to produce staple at Parkersburg. The following year the Corporation converted its Nitro plant for exclusive production of staple. Acetate rayon staple was subsequently started

at Meadville and in 1940 construction began on a new plant at Front Royal, Va., to produce both viscose rayon yarn and staple.

In May 1937 Salvage, then over 60 years of age, declined re-election to the presidency and was succeeded by William C. Appleton, a young man who for some years had been general sales manager. At the request of the shareholders, Salvage undertook chairmanship of the board until Dec. 31, 1939. Early in 1941 Courtaulds' ownership of the Corporation came to an end. Toward the end of 1940 it became evident that Great Britain needed more United States funds with which to help pay for its munitions and war equipment purchased here. To obtain these funds the British Treasury took over Courtaulds' shares in American Viscose and sold them to a group of American investment bankers, who then sold new shares in the company to American private investors.

Toward the end of the 1930's the Corporation took up production of newly developed special high-strength rayon yarn that could stand up under the severe strains imposed on tires by heavy buses and trucks. Tires containing cords required less rubber in the tire wall besides being stronger and lighter in weight. For every 1,000 lb. of high-strength rayon yarn used, there is a saving of 670 lb. of rubber, which was important during the rubber shortage occasioned by World War II.

Another project the Corporation undertook at this time was production of Vinyon, a textile fiber made from vinyl resins (vinyl chloride and acetate). Among its valuable qualities are imperviousness to water, high resistance to mineral acid attack, and complete insolubility in gasoline, mineral oils, alcohol, and glycols. It is made in continuous filament and as staple, and in high and medium tensile strengths. Its principal uses have been in industrial filter cloths, packing for pumps that handle strong acids, mesh fabrics for women's shoes and hats, also "plastic felt" hats for men, embroidery backing cloths, and screen printing cloths.

In World War II rayon fought on three fronts. Our military service called for rayon for tire cords, self-sealing gasoline tanks, several types of parachutes, and a variety of other equipment. On the home front, rayon continued to provide essential clothing for civilians. When Japanese silk imports were cut off, rayon alone kept the hosiery industry going. On the diplomatic front, rayon played a part in the State Department's policy of economic collaboration and good will between the Americas. In spite of heavy military requirements, our rayon producers were required to export a share of their production to the Latin American countries cut off from European and Japanese supplies. As the largest United States rayon producer, American Viscose was deeply engaged in all these wartime programs. Company officials cooperated closely with the War Department and government agencies and every effort was made to place rayon where it would be of the greatest assistance to the Armed Forces.

United States production of rayon increased during the war from 573,000,000 lb. in 1941 to 792,000,000 lb. in 1945. Most of this increase was due to greater production of high-strength yarn for tires and other military uses, and the Company, on government orders, expanded its Front Royal plant to double the original capacity and converted a large part of the equipment at Marcus Hook and Lewistown to high-strength rayon tire yarn.

Following the war, the Corporation converted as rapidly as possible to the types of rayon most urgently needed for civilian use. The bulk of the output was made available for the clothing and home furnishings fabrics, but the superiority of rayon cord tires had been so conclusively demonstrated that it was essential to continue [illegible] high-strength rayon in substantial quantities.

[illegible] to the future and making long-range plans for peacetime production, [illegible] evident that additional production facilities were needed. Accordingly,

the Company started at once to enlarge its Meadville and Nitro plants and in 1947 commenced construction of a new viscose rayon staple plant at Radford, Va. Starting on a very modest scale in 1910, the growth of the American Viscose Corp. is typical of America, and shows that there is still ample room for new products that give new values in our continually changing and evolving industrial economy.

ARNOLD, HOFFMAN & CO., INC., stems from a succession of partnerships starting in 1815 in a small store on Broad St., Providence, R. I. The founders were Benjamin and Charles Dyer who established the business to deal in wholesale drugs, chemicals, and dyestuffs. The Company proudly holds the longest record of continuous service in the textile industry, certainly in New England, and probably in the entire United States. From the beginning it seemed destined to pass through many hands, and the name has changed frequently. A few years after its founding, it became Henry A. Conde, and still later Dr. John H. Mason. In 1827 Dr. Mason was joined by Earl P. Mason as partner, and the name was then changed to John H. Mason & Co. In 1842 George L. Claflin, grandfather of the present head of George L. Claflin & Co., joined as clerk and shortly thereafter the name was again changed to Earl P. Mason & Co. Others in the firm under this name were Benjamin M. Jackson, George W. Snow, Levi L. Webster, and John L. Draper. As far as we can now tell about this period, the business was moved to its present location on Canal St., which it has occupied for over a century.

Mar. 31, 1869, the firm became Snow, Claflin & Co., with George W. Snow, George L. Claflin, Frank Butts, as a new member of the firm, John L. Draper, and Earl P. Mason, the latter as special partner. Mar. 30, 1872, the name again changed to Butts & Mason, with Frank Butts, Earl Potter Mason, and his son E. Philip Mason. Feb. 28, 1874, the name was Mason, Chapin & Co., the only remaining previous member being E. Philip Mason, with the addition of William P. Chapin, the new partner, Charles S. Bush, and Samuel L. Peck. During this period the father of the present president, Edward E. Arnold, joined the firm, with William Hoffman, father of W. Harold Hoffman, a present director. During these years, the firm became one of the largest importers of natural indigo. It had agents in India and among its historic relics is a picture showing the grading and weighing of indigo by natives. Indigo trading became almost extinct at the outbreak of World War I.

About 1892 the Anchor Color & Gum Works, which made colors ground in oil and fillers for paper and cloth, was acquired. Another acquisition at this time was a Paris green plant. The production of this material was dangerous, particularly with the crude apparatus of those days. No one could be persuaded to work there and this plant was soon abandoned. During this period also, the manufacture of starch and softener products was started.

Jan. 1, 1897, Edward E. Arnold and Samuel L. Peck formed Arnold, Peck & Co., with William Hoffman an interested party. Two years later Arnold and Hoffman formed Arnold, Hoffman Co. which incorporated Jan. 1, 1900, as Arnold, Hoffman & Co., Inc. Arnold served as president 25 years, until his death in 1925, and Hoffman was vice-president and treasurer until his death in 1916. In 1925 William H. Hayward, formerly secretary and later treasurer, became president; Edward E. Johnson, former secretary, became treasurer; and John R. Gladding became secretary until his death in 1931, when Johnson was made secretary-treasurer. In July 1936, upon the death of Edward M. Johnson, the son of Edward E. Arnold, Edwin H. Arnold, became treasurer and W. Harold Hoffman, son of William H. Hoffman, became secretary. Jan. 1, 1937, upon the retirement of Hayward, the stockholders elected Edwin Arnold president and treasurer; continued Hoffman a

secretary, Joseph A. Bryant as vice-president, which post he had held since 1926; elected Thomas H. Roberts, another vice-president; and Charles F. Kiess continued as assistant secretary and assistant treasurer.

The firm organized a new research laboratory in 1937 with William L. Morgan as research director and Earle D. McLeod, present head of the Research Department, his assistant. In 1938 the hurricane and flood of September completely inundated the firm's offices. The only other tidal wave to reach these proportions in Providence was the Great Blow in 1815, the year of the concern's founding. In 1940 the Company purchased the Providence Drysalters Division of the Hercules Powder Co. The business has expanded rapidly since 1937, and branch sales offices are now operated at Boston, New York, Philadelphia, and Charlotte, N. C., and resident salesmen maintained at Columbus, Ga., and Greenville, S. C.

Until 1947 all manufacturing was at Dighton, Mass. But then a new plant at Charlotte was completed better to serve the industry in the South. The Dighton plant, formerly operated as a 100% owned subsidiary, in 1946 was liquidated into the parent company. The operations can be divided into its eight departments. The Dye Department manufactures alizarin dyes for the woolen mills and new vat dyes resulting from wartime research are now in production. The Synthetic Department manufactures resins, substantive softeners, wetting agents, plasticizers, and detergents. The Size Department produces sizing compounds for all types of fabrics, also pastes and liquid printing gums for textile printing plants. The Gum or Starch Department converts or blends tapioca, potato, corn, wheat, and sago flours to produce dry adhesives, printing gums, and finishing gums. The Brokerage Department resells chemicals. (This department formerly sold entire output of Mathieson Alkali Co. prior to the death of Edward E. Arnold, its founder.) The Export Department has expanded rapidly since the close of the recent war. The Fire Specialties Department handles and markets the fire-extinguishing agent, Drench. The Machine Tool Division, the newest venture, handles coolants for cutting, grinding, and other machine tool requirements.

In the fall of 1947 Arnold, Hoffman & Co. sold to the public an issue of its capital stock. The Company is now operating at its highest capacity in history and has expansion plans far into the future.

ATLAS POWDER COMPANY was organized Oct. 18, 1912, pursuant to court decree in the suit of U. S. *vs.* E. I. du Pont de Nemours & Co. and others, establishing three separate and independent companies, of which Atlas is one. The first officers were William J. Webster, president; John F. Van Lear, vice-president in charge of sales; Walter A. Layfield, vice-president and general manager; John S. Scott, assistant general manager; and Edmund B. Coy, secretary-treasurer. Webster had had a brilliant career as head of various sales districts in the du Pont explosives organization and the other officers were all former du Pont sales, operating, and managerial personnel.

At first the Company operated only commercial explosives plants: three dynamite and four black powder, all located in Eastern and Midwestern states. It was these types of "powder" in the explosives maker's vernacular which gave Atlas Powder its name. Today, the Company's wide diversification raises a logical question, "Is it face powder, flea powder, or gunpowder?" As matter of fact, Atlas interests today are actually more closely related to insecticides and cosmetics than to gunpowder. The Company today operates, under its Explosives Department, five high explosives plants and a blasting supplies plant.

Atlas acquisition was the Potts Powder Co. in 1913, which became the the Company's Reynolds works of today, at Reynolds, Pa., the largest

Atlas dynamite plant. In 1915 the Company purchased the entire outstanding stock of Giant Powder Co., Consolidated, with plants located near San Francisco and in British Columbia. This gave the Company facilities to serve the Far Western states. The Canadian properties were later disposed of. Giant was the first American maker of commercial dynamite, manufacturing since 1868 under the Nobel patents.

The Fort Pitt Powder Co. was acquired in 1916, the Tamaqua Shops & Foundry in 1919, and the G. R. McAbee Powder & Oil Co. in 1922. These gave the Company better facilities for manufacturing and distribution in Pennsylvania and neighboring states. Further expansion in the Northwest was made by the purchase of the Puget Sound & Alaska Powder Co. in 1930. In 1932 the Company acquired the Peerless-Union Explosives Co., which was consolidated with Atlas. The dynamite plant at White Haven, Pa., was a part of the Peerless-Union assets. Purchase of American Cap Co. in 1916, with the Fort Pitt Powder Co., the Star Electric Fuze Works in 1918, and Federal Cartridge Co. in the same year, formed the nucleus for the present Atlas blasting supplies works at Reynolds, Pa.

Research in explosives began in 1916 when the Reynolds Experimental Laboratory (R.X.L.) was established under the direction of M. C. Burt, later succeeded by R. L. Hill. Under Hill's guidance, a group of explosives experts were trained, many of whom are now key employees. A pioneer in permissible explosives for use in dusty or gaseous underground operations, Hill also directed and took an active part in the development of numerous improved explosives ingredients and firing devices. During World War I, he was instrumental in forging ahead with research on the explosive nitromannite, which many years later led to the founding of the Industrial Chemicals Department of Atlas.

First diversification was the acquisition in 1917 of the Celluloid Zapon Co., Zapon Leather Cloth Co., and Richards & Co., Inc., which took Atlas into the manufacture and sale of coated fabrics and industrial finishes. Atlas saw an opportunity to utilize the excess capacity of sulfuric and nitric acid plants erected for war at explosives plants where nitroglycerin and ammonium nitrate are made. The plants in Stamford, Conn., used acid to make nitrocotton for leather cloth "dope" and for lacquers, and could also supply nitrocotton for use in dynamite. However, this division of the Company soon outgrew this original concept, and nitrating facilities at Stamford were eventually abandoned.

The history of this division has its roots in the pioneering work of Frederick Crane who first manufactured commercial nitrocellulose lacquers in 1884. The original lacquers of the Orient came from the sap of a native tree, and chemists had tried for decades to develop some counterpart. Nothing proved practical until John H. Stevens of the Celluloid Varnish Co., in New Jersey, and Richard Hale of the Frederick Crane Chemical Co., Springfield, N. J., found the key at almost the same time. In fact, patent applications were filed by both on the same day, Aug. 13, 1887, and priority suits were filed. A friendly settlement was reached by uniting into the Celluloid Zapon Co., and the factory was removed to Stamford.

Because of the mutual background in nitrocotton, the development of leather cloth closely parallels that of lacquers and finishes. The Crane Co. had erected a building and installed machinery to manufacture pyroxylin-coated fabrics. In 1891, just prior to the combination of Crane and Celluloid Varnish, it was decided that the Artificial Leather Department should not become a part of the new organization, and the Tannette Manufacturing Co. was organized and a new plant built at Bloomfield, N. J., for the manufacture of Tannette leather cloth, which possessed many desirable qualities of real leather. However, this enterprise was at first not successful due to apparent inability to produce a uniform product. In 1894 the

Bloomfield plant was closed and manufacturing activities moved back to Springfield, where a uniform product was made. Shortly thereafter, the Evans Artificial Leather Co. of Boston contracted for the exclusive use of the new pyroxylin coating compound.

In 1897 the Evans Co. was discontinued and the Boston Artificial Leather Co. organized, moved to New York, the product name changed to Morroccoline, and the coating of cloth again returned to Springfield. The John Kummer Embossing Co. of Newark, N. J., was absorbed and moved to New York. The coated cloth was sent from Springfield to New York to be embossed and shipped to customers. In 1904, owing to increased business and to poor transportation facilities then available at Springfield, it was decided to build a new plant at Stamford, Conn. Operations commenced Sept. 1, 1904, and the New York office and Decorating Department soon followed to Stamford.

At the time of the Atlas acquisition in 1917, the firm known as Richards & Co. controlled manufacturing facilities of both leather cloth and industrial finishes, while the sales of leather cloth were handled through the Zapon Leather Cloth Co. and those of industrial finishes through Celluloid Zapon. "Commodore" Leonard Richards, organizer of Richards & Co., had been with the interests since 1886, when he and Frederick Crane were cofounders of the Frederick Crane Chemical Co. He retired shortly after Atlas took control. His son, Leonard Richards, Jr., became a director of Atlas, and was vice-president and director of purchases in Wilmington until his death in 1946.

Both the finishes and leather cloth operations have been greatly expanded by research and development of better products requiring increased facilities, and by acquisition of other properties. The Duratex Corp., Newark, N. J., was acquired through Richards & Co. in 1928, greatly strengthening the Stamford operations, especially in rubber-coated fabrics for automobile top materials, etc. Duratex had originated in the leather industry, when the Johnson Leather Co. about 1903 began to manufacture split leather for the carriage trade. The company began to make artificial leather for the automobile industry about 1916, under the trade name Duratex.

In 1937 Atlas purchased Revolite, a Bakelite resinoid-coated fabric formerly manufactured by Revolite Corp., a Johnson & Johnson subsidiary. Most recent acquisition in coated fabrics was the Keratol Co., Newark, N. J., which was purchased in 1941. Established in 1898, Keratol had become a well-known and successful manufacturer of artificial leathers, upholstery and book-binding fabrics, and other coated fabrics, principally of the "light-weight" type, as distinguished from the heavier types of coated fabrics made at Stamford. Personnel and manufacturing equipment moved to Stamford, consolidating the two plants. All coated fabrics operations are now included in the Zapon-Keratol Division, which, with the Zapon Division (industrial finishes) makes up the Cellulose Products Department of Atlas. Until May 16, 1947, this department was headed by Jacob K. Weidig, who had been associated with the old Keratol Co. as its general manager, and had been an officer and director since 1915. He has been succeeded by Ed H. Bucy.

In the expansion of industrial finishes operations, the acquisition of the Brevolite Lacquer Co. of North Chicago, in 1933, is important. The Zapon industrial finish trade had been steadily expanding westward, and it was decided that a branch factory rather than a warehouse was the better way to serve the Midwest trade. Brevolite had its beginning in 1919, when the former Waukegan Chemical Co. was formed, financed by L. R. and E. H. Wilder. Dr. Rudolph Breves, who died in [illegible] and Casper Apeland, now general manager of the North Chicago plant and [illegible] the personnel. Ed H. Bucy came to the company in 1921, and soon

became chief chemist, later vice-president. The name became Brevolite Lacquer Co. in 1930, adopting part of Dr. Breve's name, and the prefix "Brev-" is still evident in many of the company's trade names for industrial finishes. Bucy went to Stamford in 1934 as technical director of the Zapon Division and is now general manager of the entire Cellulose Products Department.

To maintain leadership in the rapidly changing and highly competitive fields of finishes and coated fabrics, research and sales service laboratories are maintained at the finish plants in Stamford and North Chicago, and at the coated fabrics plant in Stamford.

The beginnings of the large Atlas research organization of today and the origin of the newest Atlas diversification into polyhydric alcohols go back to the year 1917. Then Atlas chemists were casting about for a suitable substitute for glycerin, which was scarce due to war needs and sorely needed to make nitroglycerin for dynamite. It was decided to investigate the possibilities of producing mannitol by the electrolysis of sugar. Mannitol is a relatively scarce alcohol related to glycerin and was imported in small quantities from Mediterranean countries. If sufficient mannitol could be obtained, it might be possible to make a suitable explosive by nitrating it. Dr. H. Jermain Creighton of Swarthmore went to work on the project, with Kenneth R. Brown, one of his students. He had just demonstrated that mannitol could be produced by electrolysis, when the Armistice came, and the research was abandoned. Meanwhile, Brown had been offered a position on the research staff of Atlas and accepted. He is now research director and board member.

The search was again taken up six years later, with an entirely different objective. It was proposed to manufacture both mannitol and sorbitol by the electrolytic process. Mannitol might be nitrated to make a safer explosive for blasting caps, various medicines, and other chemicals. Sorbitol could be used as a moisture-conditioning agent like glycerin or it could be reacted with other chemicals to produce new materials. At first the explosives possibilities of mannitol assumed most importance in the Atlas laboratories, which had been primarily set up for working out explosives problems. Gradually it was realized that the possibilities of the new polyhydric alcohols merited study entirely apart from any relation to explosives. Certain personnel were delegated to this study, establishing themselves in an old brick building a few yards from the explosives laboratory at Reynolds. Thus began, in 1932, what has grown into the Atlas Research Department, whose sights are set not on the future of any one product, but on the future of the entire Company. Personnel, facilities, and new problems for research have so multiplied with the years that in 1944 the first of an entirely new group of research buildings was completed near Wilmington. Still further units were completed in 1947, when the last of several pilot-plant projects at Reynolds were moved to the new Central Research Laboratory at Wilmington.

The original research on making mannitol and sorbitol has grown into a full-fledged industry comprising an entire product department of Atlas. In 1936 a $1,000,000 plant on the Delaware River near Wilmington started operation. Its capacity was small and almost entirely limited to these two polyhydric alcohols. Since that time, the plant has doubled and tripled capacity several times. Dozens of derivatives of the alcohols are now produced in addition to the original products.

The search of long ago for a safer explosive has been all but forgotten. That particular use of mannitol, naturally, is relatively minor, though Atlas today has made well over 500,000,000 safer detonators through the use of hexanitromannitol, an initiating compound trade-named Manasite. This compound has also found wide medical use as a vasodilator in the treatment of arteriosclerosis. The big story of

the expansion of this department of Atlas lies in sorbitol and seemingly endless derivatives from both sorbitol and mannitol. Sorbitol itself has two main uses. One is as the starting point in the synthesis of vitamin C and resins and drying oils for paints, varnishes, and lacquers. The other is as a humectant or moisture-conditioning agent for leather, paper, printers' rollers, baked goods, shoe polishes, tobacco, cosmetics, flexible glues, gelatin capsules—and even dolls' heads! The possible combinations of sorbitol and mannitol with other compounds runs close to half a million —more than all the organic compounds at present known. Several hundred have already been produced by Atlas. Dozens are in popular use as emulsifiers, softeners, insecticides, plasticizers, and resins. Research on their boundless possibilities is being carried not only at Atlas, but by many other interested concerns, universities, and affiliated research groups.

The fifth product line of Atlas is its subsidiary, Darco Corp., which is not wholly owned. Darco operates one of the world's largest plants for the manufacture of activated carbons, at Marshall, Tex. Its various grades find important use in refining sugar and many industrial chemicals, including some made by Atlas; in purifying dry-cleaning solvents and electroplating solutions; in decolorizing and purifying fats, oils, and other foods. In recent years they have also found wide application in producing penicillin and streptomycin. Atlas' first connection with Darco came in 1921, when Atlas entered into a contract to construct and operate a plant upon a fee basis and one-third interest in the common stock of Darco Corp. At that time Darco was operating a small plant at Houma, La. The Marshall plant was completed the following year. During the intervening years Atlas has gradually acquired over 90% of the preferred stock and nearly 80% of the common stock of Darco Corp.

Officers of Atlas Powder Co., 1948, are: Isaac Fogg, president; Maynard J. Creighton, Frank S. Pollock, and Weston G. Frome, vice-presidents; Thomas M. Eliason, treasurer; Harry B. Hygate, secretary; and P. W. Parvis, assistant treasurer and assistant secretary. Leland Lyon is chairman of the board, which includes Fogg, Creighton, Pollock, Frome, Eliason, and also Charles C. Gammons, Edward W. Maynard, Cecil F. Backus, Charles Warner, James R. Frorer, and Kenneth R. Brown.

The general managers of the four product departments of Atlas are: Weston G. Frome, Explosives; Ed H. Bucy, Cellulose Products; James R. Frorer, Industrial Chemicals; and L. M. Gill, Darco Corp. William T. Penniman, who was a vice-president and director from 1930 until his death in 1942, was one of the leaders of Atlas during this period of its growth and among those largely responsible for its assistance to the Government in operating ordnance plants and producing ordnance matériel for World War II. He came to Atlas when the Company was organized, as credit manager and later comptroller. In 1922 he became vice-president and managing director of Northern Giant Explosives, Ltd., an early subsidiary in British Columbia, and was later made president. He became general manager of the Explosives Department of Atlas in 1930.

Going back to the 1913 records of Atlas, the growth in workers, stockholders, and material assets can be traced. Then the total number of employees was 600-800. Today, it is about 4,000. The number of stockholders has grown from 756 to nearly 5,000. An original funded debt of $3,000,000 has been wiped out and the Company total assets are nearly $32,000,000, compared with less than $8,000,000 in 1913 Originally there were only seven plants, all making explosives. Today, ... six explosives plants, most of them representing consolidations of several ... The more important fact is that Atlas made a healthy diversification

into numerous other fields—industrial finishes, coated fabrics, polyhydric chemicals, and activated carbons.

J. T. BAKER CHEMICAL COMPANY is the projection of an individual personality who stands out as a high light in the advancement of science and industry in this country. John Townsend Baker contributed that personality, destined to establish our domestic reagent chemical industry. He was born at Orange, N. J., in 1860. While completing his education at Lafayette College, his keen mind, absorbed in the study of chemistry, recognized the need for high-quality reagent chemicals not then available.

In 1882 he started a chemical business which he sold out at a handsome profit in 1902. He remained in a key position with the business, but in 1904 started his own J. T. Baker Chemical Co., organized under the laws of New Jersey with authorized capital of $500,000. The site selected for the Company was Phillipsburg, N. J., based on the economic advantages of nearness to Eastern markets with access to the seaboard through New York or Philadelphia. Additional economic advantages have been close proximity to the coal fields, favorable facilities afforded by four railroads, and an abundant water supply from the Delaware River and adjacent tributaries.

Among Baker's early associates who contributed manufacturing know-how and administrative ability was William P. Fitzgerald, who became associated with him in 1904 and until his death in 1942 was chief chemist. Charles D. Davis, the Company's first treasurer and plant superintendent, joined the organization in 1904 and ably managed these posts until his retirement in 1941. Herbert H. Garis, who joined in 1905, was very largely responsible for the rapid growth and strong financial position of the business. He was sales manager, became vice-president in 1923, and in 1926 (when Baker became chairman of the board) was made president and general manager. Russell H. Willever, another pioneer from 1907, advanced to treasurer in 1930, to secretary and treasurer in 1935, becoming Garis' right-hand man.

The officers of the Company have been as follows: chairman, J. T. Baker (1926-34); president, Baker (1908-25) and H. H. Garis (1926-47); vice-president, Garis (1923-25), W. P. Fitzgerald (1926-41), R. A. Clark (1942-47); treasurer, C. D. Davis (1904-29), R. H. Willever (1930-47); secretary, J. T. Teeple (1904-7), Garis (1908-22), Fitzgerald (1923-25, 1930-34), Davis (1926-29), Willever (1935-47).

The idea on which Baker founded the business was the production of a line of C.P. reagent-quality chemicals as near to being actually chemically pure as possible, and showing on the label of each bottle the exact amounts of the slight impurities present as found by the Company's analysts. Being the first to show an analysis of impurities on the label of reagent chemicals gave the Company a national reputation.

Practically no progress was made the first two years, so in 1906 the contract with a New York selling agency was canceled and Garis was put in charge of advertising and selling. Through a persistent mail campaign to chemists (out of this developed the present *Chemist Analyst* now going to 40,000 chemists), the idea of the "Analysis on the Label" was sold and chemists began to specify "Baker's Analyzed." Up to 1925 the Company relied entirely on mail advertising and selling, but plant facilities had been expanded and R. A. Clark was employed as the Company's first traveling salesman, later made sales manager with instructions to expand and train a national sales organization.

As the Company progressed in manufacturing know-how, it expanded into

other fields. As a consequence of economic demand and adaptability of plant facilities and organization, a second branch of the business developed in 1931: pharmaceutical and fine chemicals. Because of the reputation of "Baker's Analyzed Chemicals," consumers quickly accepted these new products of the Company. Additional outlets were sought and the dream of an industrial chemicals division soon became a reality. With additional demands and natural requirements for lower costs through engineering and technological advancement, increased operating facilities were required. To provide for these, additional capital was added in 1936 through stock subscription. The Company expanded further through the purchase of the Taylor Chemical Corp., manufacturers of carbon bisulfide.

The Company's research program for many years has been devoted to process development and refinement. A staff of chemists and chemical engineers has sought to improve current production and add new products. The rapid expansion of the Company is evidence of the results of this work.

In 1941 the Vick Chemical Co. purchased the capital stock of J. T. Baker Chemical Co., which operates as a subsidiary with the same officers in charge. Baker's ability to produce specialized chemicals during the war years provided numerous additional markets and resulted in the initiation of an organic division in 1944. A broad program of development in this field has resulted in greater diversification of products and rapidly increasing sales volume.

BARRETT DIVISION, Allied Chemical & Dye Corp., has a history almost synonymous with the development of the coal-tar industry in the United States. About 1850 coal tar was a troublesome by-product of plants which made illuminating gas by distilling bituminous coal. It had little known value and presented a disposal problem. Gradually a few uses were developed, one of the earliest being as a saturant for muslin in roof construction. Later the waterproofing properties of coal-tar pitch were put to use on roofs, ironwork, and masonry. Materials having solvent qualities and oils for wood preservation and for manufacture of tar and pitch paints, were also among its early products. From these humble beginnings coal tar has become the source of a multitude of materials: dyes, medicines, disinfectants, perfumes, flavors, plastics, resins, and explosives—these, and many more.

Barrett's original predecessor company began business in 1854 as a manufacturer of tar-saturated muslin and coal-tar pitch for roof construction, and by the middle seventies had become a leader in its field. Between 1889 and the late nineties, the firm expanded by acquisition of a number of Midwestern and Eastern tar-processing companies, and, in 1896, the Barrett Manufacturing Co. was formed. One of these companies, the H. W. Jayne Chemical Co. of Philadelphia, located on the site of Barrett's present Frankford plant, had been established in 1884 to make refined coal-tar products. Aware of German developments in this field, the Jayne Co. was pioneering in this country in solvents and other coal-tar chemicals in pure form.

Up to 1892, illuminating gas plants were the only source of coal tar, and as the quantity produced was relatively small, tar-distilling operations were correspondingly limited. Distillers were becoming concerned over the possibility of inadequate supplies of tar. In that year the Solvay Process Co. erected at Syracuse, N. Y., the first by-product coke ovens in the United States to furnish coke and ammonia it required in the production of soda ash and caustic soda; the by-product tar was sold [illegible] Barrett. The Syracuse by-product coke plants having proved a technical success, [illegible]lvay Co. was formed in 1895 to promote the by-product coking process in [illegible] American interests later promoted other types of by-product

coke plants. With the growth of the by-product coke oven industry, supplies of coal tar became more plentiful and the tar distillation industry was greatly stimulated.

The new type of coke oven held another attraction for Barrett. As early as 1890, the Company was promoting the use of anhydrous ammonia recovered at its Edgewater, N. J., plant from waste gas-liquors produced at illuminating gas plants. It thus took an immediate interest in the relatively large quantities of ammonia liquors, and often of ammonium sulfate, produced as by-products from the new coke ovens. Then as now, the principal use of sulfate of ammonia was as fertilizer and thus, more than half a century ago, Barrett began the promotion of nitrogen for agriculture.

By 1902, almost 1,700 by-product coke ovens were operating at 10 locations in the United States, producing annually about 25,000,000 gal. coal tar—an amount approximately equal to that produced by all the widely scattered illuminating gas plants. Moreover, nearly 1,900 additional ovens were under construction, capable of producing 25,000,000-30,000,000 gal. coal tar annually.

In one decade by-product coke ovens had outstripped illuminating gas plants in total coal-tar production. By 1902 they were producing annually about 10% of the country's coke. Barrett could not, of course, foresee the expansion in coking facilities incident to World War I, but it did estimate the dimensions of its problem by considering what would happen if by-product coke ovens completely replaced beehive ovens. From 50,000,000 gal. tar in 1902, annual output would rise to 250,000,000 gal. and production of ammonium sulfate and crude benzene would increase more than tenfold. The modern American coal-tar industry dates, therefore, from about 1903-04, when economic pressure against beehive ovens was rising and when Barrett, the only tar distiller on a nation-wide scale, undertook preparation for major expansion.

In 1903 the American Coal Products Co. was organized to bring into one organization the resources, technical information, and personnel of the Barrett Manufacturing Co. and the United Coke & Gas Co. An immediate start was made to enlarge facilities and to install continuous processes where feasible to handle the greatly increased supply of coal tar. Tankcars, barges, and tankers began to supersede barrels for receiving tar and for shipping tonnage products. Outlets of great potential magnitude had to be developed, and only through standard factory practices and products meeting standard specifications could the necessary volume outlets be maintained. Soon Barrett was releasing its standard methods and specifications—many of which gained and still have world-wide acceptance—and Barrett products became known for quality and uniformity. This forward-looking concept of standards was a great contribution to American chemical industry.

Efforts toward standardization revealed that lack of use-standards often led to inferior results and sometimes complete failure. This was true, for example, in the field of built-up roofing, a principal outlet for coal-tar pitch. The Barrett SPECIFICATION roof ultimately evolved, embracing standards for tarred-felt, pitch, and mineral aggregate, and for method of application to various types of roof decks. The whole plan, including a guarantee bond protecting the building owner against failure due to faulty materials or workmanship, met with immediate favor and has long since become standard roofing practice.

Coal tar and coal-tar pitch, in early use for construction of sidewalks, had been employed to a limited extent as binders and waterproofing media in road construction. Rapid development of the automobile called for substantial improvement in roads and Barrett undertook intensive research and engineering development on coal tar and coal-tar pitches in highway construction. Technical requirements were determined, standard specifications, laboratory apparatus, and techniques de-

veloped, and standard methods of construction established. TARVIA, Barrett's trade-marked name for its highway materials, played an important part in adapting the country's highways to the automotive era, and became known around the world.

In its efforts to find outlets for growing quantities of coke-oven light oils, Barrett increased refining activity at its Frankford plant. Standards and specifications were developed on pure benzene, toluene, xylene, solvents, and related coal-tar hydrocarbons. By 1911 Barrett was marketing a number of coal-tar light oil products with well-defined physical properties and uses. Pure benzene and toluene were bases for other materials such as nitrobenzene and benzoic acid, and components of cements and coatings for food product cans. Uses of technical grades included manufacture of tires, rubber cement, artificial leather, paints, varnish removers, and thinners. Barrett also produced pure naphthalene, best known to the public as moth balls, but also the parent substance of β-naphthol, α-naphthylamine, phthalic acid, and other dye intermediates. Outlets for large quantities of distillates were developed for lampblack oils and coal-tar disinfectants. Carbolic acids, cresols, and cresylic acids shortly were in manufacture.

Although since 1840 England and Continental Europe had used coal-tar creosote oil to protect timber such as railroad ties and marine piling, early attempts to introduce the material in this country were largely unsuccessful. The effectiveness of treatment, which then employed the so-called "full-cell" method, was recognized; but in view of the plentiful supply of wood, the cost was generally considered prohibitive except in special situations. Advancing timber prices and other economic factors focused attention on methods of wood preservation, however, and increased the number of situations in which it was practicable to creosote timber. About 1903 or 1904, trial began here of the "empty-cell" method of treatment, in which the wood, under air pressure, was completely filled with creosote which was then in part expelled by release of the pressure. Protection was thus accomplished with only about one-half to one-third as much creosote as in older processes, so that cost was no longer a deterrent to large-volume use of creosote, and immediate growth in consumption began.

From the American producer's point of view, a problem arose in the disposal of the enormous amounts of coal-tar pitch resulting from large-scale production of creosote oil. The English producers, having an established briquet-pitch market in Europe, were not faced with this problem and were usually able to make supplies of creosote oil available in the United States at prices which domestic tar distillers were unable to meet. Barrett pressed its search for markets for pitches and coal-tar chemicals in large amounts and for processing methods adapted to great volumes of tar. Markets steadily developed with the country's increasing industrial activities, and Barrett installed continuous tar-distillation apparatus of large capacity. Today, annual consumption of creosote oil is over 200,000,000 gal. and Barrett is the leading producer.

In the field of coal-tar dyes, requirements of manufacturers for intermediates had grown substantially by 1910, and in that year, Barrett, Semet-Solvay, and General Chemical Co. formed Benzol Products Co. to perfect processes and manufacture nitrobenzene, aniline, aniline salt, and other synthetic coal-tar chemicals. Development and production were at Barrett's Frankford plant until 1915, when operations were transferred to Benzol Products' new plant at Marcus Hook, Pa. The operations were ultimately removed to National Aniline & Chemical Co.'s works at Buffalo, N. Y.

By the outbreak of World War I, Barrett had founded the following four main [illegible] manufacture of coal-tar chemicals and their derivatives; refining [illegible] materials, creosote oil, and pitches; manufacture of roofing

and protective coatings; distribution of coke-oven light oil products and nitrogen materials as sales agent for producers. World War I accelerated construction of by-product coke ovens, then the only economical source of the great quantities of benzene, toluene, xylene, and other coal-tar chemicals required for synthetic phenol, picric acid, ammonium picrate, and TNT. In 1918 coke-oven tar production was almost 290,000,000 gal., approximately double the 1913 output.

The Company enlarged its production of benzene, toluene, and naphthalene; made synthetic phenol; became one of the first American manufacturers of α-nitronaphthalene and α-naphthylamine; produced refined anthracene; developed large-scale production of *m*-xylene, raw material for military explosives; aided rubber, paint, and varnish manufacturers to find suitable replacements for benzene, toluene, and xylene no longer available as solvents; undertook increased production of tar acids required for disinfectants and in demand by the growing phenolic-resin industry; produced pyridine and other tar-base fractions; introduced and pioneered use of *p*-coumarone-indene resins; and developed and manufactured resorcin. Enormous amounts of distillates went to the new flotation plants of the copper industry.

Barrett's association with the great expansion in coke-oven by-products and the evolution of consuming industries furnished a preview of postwar problems and opportunities and laid the groundwork for a program of extensive research and development. New outlets for coal-tar products were sought, with applications-research greatly extended. Raw materials, operations, and finished products were critically examined; opportunities for improvement evaluated and in large measure effected. Long-range research led to the process for vapor-phase catalytic oxidation of benzene to maleic anhydride. Catalytic oxidation of anthracene to anthraquinone and of naphthalene to phthalic anhydride followed, the latter soon being converted to synthetic anthraquinone. Maleic anhydride was converted to maleic, fumaric, malic, and related acids.

The displaced beehive coke oven was put to use by Barrett for conversion of large quantities of coal-tar pitch to a form of pitch coke which represented a great advance and still remains the standard of quality. A laboratory was established to conduct research on the utility of coal-tar products in rubber. From this effort came Barrett's line of products designed for rubber compounding. After the Allied consolidation in 1920, Barrett's catalytic oxidation product-development and manufacture, then regarded as closely related to dye-manufacturing operations, were transferred to National Aniline & Chemical Co., as was production of α-naphthylamine.

In recent years, Barrett has extended interest in synthesis of chemicals important as raw materials for such products as synthetic resins and plastics, synthetic coatings, and rubber. In 1937 it installed the most modern unit for catalytic oxidation of naphthalene to phthalic anhydride and has continued expansion of such facilities. A new synthetic phenol plant followed in 1938. Processes were developed for manufacture of cyclohexane, cyclohexanol, cyclohexanone, and their homologs by continuous vapor-phase hydrogenation of coal-tar products.

Since the early 1930's, Barrett has played an important part in expansion of the country's system of natural gas and petroleum pipe lines, trunk water-supply systems, and in protection of penstocks and the like by coal-tar pipe coatings and products developed to meet requirements of extreme conditions of temperature, corrosion, and abrasion. Hoover Dam, the Los Angeles water-supply system, and the Big Inch petroleum line testify as to the efficiency of the service rendered.

During World War II, improved facilities were installed for manufacture of esters, such as dibutyl phthalate, dicyclohexyl phthalate, and others, all wartime essentials and in growing demand as plasticizers and solvents in synthetic resins,

plastics, coatings, and rubber. Barrett roofs were widely used on war factories, cantonments, and other military establishments. TARVIA road tar was used in construction of numerous airports and access roads. Fractions which Barrett had long supplied to the rubber industry did much to make synthetic tires and other products possible. Barrett also became one of the largest producers of nicotinic acid, an important synthetic chemical-component of the vitamin B complex. Research conducted for the Government during the war included development of a bituminous coating for bomb cases, a component for aviation gasoline, and a process for producing picric acid directly from benzene.

In addition to its other activities, Barrett has since about the beginning of the 20th century rendered valuable services to the American farmer. As agent for numerous producers, it has distributed nitroger products nationally and cooperated with government bodies in scientific use of nitrogen fertilizers. In 1929 Barrett, through its Sales Agency Department, successfully introduced synthetic nitrate of soda to farmers, and in 1934 commenced distribution of ammonia liquor solutions of ammonium nitrate to the mixed-fertilizer trade. It has also served manufacturers of mixed fertilizers by research in that field, making results available to the entire industry.

For almost a century Barrett's name has been synonymous with coal-tar products. For more than 50 years it has represented nitrogen for agricultural and other needs. Events appear to have confirmed the soundness of concepts which directed the Company to its four lines of endeavor. As in the past, Barrett is developing through intensive research new products, new uses for existing products, and improved productive processes.

BATTELLE MEMORIAL INSTITUTE, today one of the world's leading organizations for industrial research, was conceived to fill a need that arose in the maturing industrial pattern of the United States. During World War I, Gordon Battelle, son of Col. John G. Battelle, pioneer in the iron and steel industry in Ohio, was engaged in mining and smelting operations in the Joplin, Mo., area. Here he became acquainted with a scientist and former professor, W. George Waring, who had undertaken to develop a process for recovery of commercial values from mine tailings and mine water. Battelle became interested and built a small laboratory for Waring. This resulted in the successful completion of the process, which was then taken to a commercial laboratory for economic appraisal. Out of this experience, the young heir to one of Ohio's great industrial fortunes obtained a profound respect for research as a means of solving industrial problems and an appreciation of the inadequacy of then-existing research facilities. He foresaw in the teaming of science and industry an opportunity to bring many benefits to mankind. He gave much thought to the problems of research organization and how to make research facilities generally available, spending nearly a year visiting laboratories throughout the country to gather ideas for the formulation of a plan of action.

What course Gordon Battelle's efforts might have taken had he lived will never be known. In 1923 he died, at the age of 40, but his dream of improving the lot of mankind through science was not to be thwarted, for he left the bulk of his estate "for the foundation of a Battelle Memorial Institute . . . for the purpose of education . . . the encouragement of creative research . . . and the making of discoveries and inventions in connection with . . . metallurgy, coal, iron, steel, zinc, and allied industries." The will named as original trustees Bishop John W. Hamilton, then [illegible] of American University; President Warren G. Harding; Annie Norton [illegible] mother; Joseph H. Frantz and Harry M. Runkle, business asso-

ciates. The present board of trustees includes R. C. Allen, president; J. C. Miller, first vice-president; Albert H. Thomas, second vice-president; Dr. Zay Jeffries; Gerald B. Fenton; and Runkle.

The original endowment was more than doubled two years later when Mrs. Battelle died, leaving most of her estate to augment the endowment of her son. Shortly thereafter, construction of a laboratory building was begun in Columbus under the direction of Dr. Gerald Wendt. In 1929 the Institute was formally opened and Gordon Battelle's plan of making research facilities available to industry was put into operation. The initial staff consisted of 20 scientists and assistants, under the directorship of Dr. Horace W. Gillett—one-time associate of Thomas Edison—who was recruited from the Bureau of Standards where he had been chief of the Division of Metallurgy. Dr. Gillett remained as director until 1934 when he turned his full time to the technical direction of research. Clyde Williams, present director of the Institute and one of the original assistant directors, replaced Gillett, who has since served as the Institute's chief technical advisor.

Since the enterprises of the Battelle family had been concerned with iron, steel, coal, and nonferrous metals, it was natural that the first research efforts of the new Institute be in metallurgy and fuel technology. These led into related fields, such as ceramics, chemistry, electrochemistry, physics, and organic chemistry, and as the Institute grew it gradually branched to include within its scope practically all major branches of industrial science and many highly specialized technologies.

To serve the altruistic objectives of its founder, Battelle was incorporated as a corporation not-for-profit. Its endowment funds were spent liberally to provide the physical plant, the best scientific equipment available, and to staff the Institute with the highest type of scientific man power. The unexpended portion of the endowment was invested by the trustees as a perpetual trust, the income from which is used to finance fundamental scientific research and maintain a program of research education, and for physical expansion.

In keeping with the wishes of the founder, the board of trustees also initiated the Institute's unique research-for-industry plan. This plan brings within the reach of all industry—even companies with the most limited research budgets—the finest scientific equipment and technical ability for solving private research problems. Under the plan, the sponsoring company pays for the cost of staff time, materials, and incidental expenses in connection with a research project and retains complete rights to all developments coming from the research. Thus, the company unable to make large capital investments for a research laboratory may secure all the advantages of one. In effect, the Institute is the private "research laboratory" of each of its sponsoring companies.

A program of training young scientists for industrial research was set up by the Institute as one means of executing the founder's educational provision. Under the program and through cooperative arrangements with participating universities, young scientists with bachelor degrees are trained in practical research methods while carrying on their academic graduate work. The plan has enabled scores of students to continue their education and has supplied industry with trained personnel for responsible research positions.

Though the period since its founding in 1929 has been one of almost continuous national calamity—first depression, then war, and then inflation—the Institute has exhibited constant growth in physical plant, in personnel, and in the volume and scope of its research. Its original building, containing 90,000 sq. ft. of floor space, has been enlarged by construction of an east wing and supplemented by the erection of three large laboratory buildings, several small pilot-plant structures, and a large suburban agricultural laboratory. In addition, the Institute has leased a six-story

office building in Columbus for laboratory purposes and several smaller buildings for use as warehouses. Its physical plant in 1947 totaled approximately 400,000 sq. ft. of floor space. In personnel the Institute's growth has been even more rapid. The original staff of 20 had grown to more than 1,000 in 1947. Likewise, the volume of sponsored research had increased geometrically—from $80,000 in 1933 to an estimated $4,250,000 in 1947.

The diversity of the activities of the Institute is illustrated by two research investigations that were in progress at one time. One was concerned with improvements in the commercial growing of chrysanthemums; the other had as its objective a new design for a coal-burning locomotive. Between chrysanthemums and locomotives, it is difficult to conceive a problem not within the Institute's scope.

Battelle contributions of major importance to industry have been in the solution of hundreds of technical problems pertaining to industrial materials and processes. These contributions are highly technical, seldom dramatic, and thus rarely known to the general public. For these technical contributions the Institute has earned an enviable reputation of service and scientific integrity among technologists.

The public is acquainted with the smokeless stove that the Institute developed as one practical answer to the smoke-abatement problem; it knows of the ship paint that keeps ships free from barnacles; it buys watches containing mainsprings made from a Battelle-developed noncorrodable alloy; and it has heard of an electronic measuring instrument which measures to one-tenth of a millionth of an inch. Battelle is also associated in the public mind with the electropolished surfaces on metallic household articles, with free-machining steels, with longer-lasting lubricating oils, with increased yields in tobacco acreage, with better fountain pen inks, with acoustical building plaster, with certain new types of pulverized-coal-fired furnaces, and with numerous other developments.

The entry of the United States into World War II saw Gordon Battelle's dream of a research center to aid industry a well-established and functioning reality, and the fact of its existence aided immeasurably in the prosecution of the war. A "war of technology," practically all of the scientists of the staff of the Institute were mobilized for their special talents and skills. Battelle's director, Clyde Williams, was made head of the country's metallurgical research efforts and was able to call upon many of his own group for assistance. Almost overnight, the Institute became a "manufacturing plant" of war-vital engineering and scientific information. Research was conducted for the Army, Navy, War Production Board, and their various subagencies, including the Manhattan District Project. When the smoke had cleared from Nagasaki, it was revealed that approximately 400 members of the Institute's staff had contributed to the development of the atomic bomb. The commendation "invaluable to the success of the atomic program" was added by Maj. Gen. Leslie R. Groves to the high praises already bestowed upon the Institute by the chiefs of ordnance of both the Army and Navy.

Battelle is characterized by a minimum of departmental organization. The resultant flexibility permits the full exercise of staff talents and insures the concentration of all needed talents and skills on each research project. J. S. Crout, D. C. Minton, V. H. Schnee, and B. D. Thomas are executive assistants to the director. Seven assistant directors are charged with the technical coordination of all research activities: Dr. O. E. Harder, Dr. Frank C. Croxton, Dr. Clarence H. Lorig, Dr. Howard W. Russell, Ralph A. Sherman, Clarence E. Sims, and John D. Sullivan.

Although still a comparative infant in the American industrial picture, Battelle is now an important part of it. Gordon Battelle dreamed of a center where industry [illegible] turn for technological information. Before the 18th anniversary of its [illegible] 15,000 representatives of business and industry were visiting Bat-

telle annually in search of answers to technological problems. The infant is helping shape the country's industrial destiny.

BAY CHEMICAL COMPANY, INC. can be credited to the late Emanuel V. Benjamin, whose primary purpose in starting the Company's operation was the establishment of a new outlet for salt. Myles Salt Co., Ltd., owning and operating a large salt deposit of extreme purity in Iberia Parish, La., started building a chemical plant late in 1924. This was completed and in operation by the fall of 1926. It soon became evident that chemicals could be marketed to better advantage through a special sales organization, and Bay Chemical Co., Inc., was chartered for this purpose in 1928. In 1930 Myles Salt transferred its chemical plant and business, other than salt production, to Bay Chemical. Since that time Myles and Bay have been conducted as distinct and separate entities. The Morton Salt Co. of Chicago acquired the Benjamin and Mente interests in 1947.

At the time Bay Chemical Co. was founded, the officers of both Myles and Bay were Emanuel V. Benjamin, president; Eugene W. Mente and Edward B. Benjamin, vice-president; and Robert H. Polack, secretary-treasurer. Present officers of Bay Chemical are Daniel J. Peterkin, Jr., president; J. A. Clements and Robert H. Polack, vice-presidents; Wesley H. Sowers, secretary; and Garfield King, treasurer.

The first chemical production contemplated was sodium sulfate (salt cake), for which a ready and expanding market existed in the kraft paper industry, one of the South's most rapidly growing businesses at the time. After investigating various production methods, the Company adopted a modification of the Hargreaves process. The original Hargreaves patent had never been used in America but a Hargreaves plant operated in Europe. Accordingly, a chemical engineer who had assisted in the design and erection of the first Hargreaves plant in 1875, was brought to the United States as a consultant. E. V. Benjamin, Sr., though not a chemist and without technical education, designed and patented the plant to carry out the modified Hargreaves process, this plant being built along lines entirely different from any previously in operation. New outlets were needed for the large quantity of muriatic acid made jointly with sodium sulfate in the venture. At that time very little muriatic acid was consumed in the South. In this connection an outstanding German chemist was brought over. After some research the Company determined to consume its acid in manufacturing dicalcium phosphate for fertilizer and in animal feeds. Dicalcium phosphate proved so efficacious in feeds that Benjamin, Sr., instituted research on its use in human dietetics. The results proving dicalcium phosphate of outstanding value for calcium and phosphate deficiencies, the Company prepared to make the product commercially on a large scale, which had not been done heretofore in this country. Thus Bay pioneered the research and production of dicalcium phosphate for human consumption in America.

Due to the serious depression in agriculture and in the livestock industries when the Company's plant was built, the marketing of dicalcium phosphate for fertilizer and animal feeds proved unprofitable and as a result Bay discontinued the manufacture of all phosphate products in the early thirties. At about the same time new uses arose for hydrochloric acid, providing a market for this product in volume and on a more profitable basis than in the manufacture of phosphates. As kraft paper manufacture increased in the South, the Company boosted its sodium sulfate output.

Because of their essential nature, Bay products played a very important role in the recent war effort. Most of the Company's output is sold on yearly contract, partly through a sales agent and partly direct to consumers.

From its inception the Company conducted a small amount of research, but as

time passed this was stepped up to develop new uses not only for Bay's own products but also for raw materials and resources available in its area. Outside consultants and laboratories are employed on specific problems from time to time. Research fellowships have been established at Tulane University in New Orleans, and the Company has cooperated with government regional laboratories on projects.

Outstanding achievements, in addition to the development of Bay's own processes, comprise a method and design of plant for making dry hydrogen chloride simply and inexpensively, and processes for making rubber hydrochloride, rubber hydrochloride stabilizers, and furfural stabilizer. There has also been developed a lumber-curing product that reduces degrade, checking, and the drying time of lumber in both kiln and yard drying. The Company has obtained several patents which it feels will make noteworthy contributions to the chemical industry in the not too distant future.

BENZOL PRODUCTS COMPANY being from the first closely identified with Dehls & Stein, Inc., the activities of both concerns are inseparable. Since 1906 Dehls & Stein had been actively engaged as analytical and manufacturing chemists, with offices and factory in N. Y. City. In 1914 the firm outgrew its quarters and moved to 237-243 South St., Newark, N. J., where it purchased a lot bounded by South, Pacific, and Thomas Sts. In the early twenties the firm branched out from the manufacture of technical chemicals to fine organic chemicals, the first made being *p*-aminophenol and diethylaniline. In 1924 negotiations were consummated with Pfaltz & Bauer and Joseph Ebert, owners of the Ebeco Chemical Co., manufacturers of fine chemicals, to buy out their holdings and manufacturing facilities at 13 Margaretta St. in Newark. The name Ebeco was discarded and the new company, Benzol Products Co., a New Jersey Corporation, was organized May 15, 1924. At this time Dr. Leo Stone was chosen president, John C. Dehls, treasurer, and Joseph Ebert, vice-president and secretary. The Company consolidated the manufacture of fine organic chemicals formerly undertaken separately by Dehls & Stein and Ebeco. Dehls & Stein continued as a separate entity in its capacity of analytical and manufacturing chemists.

John C. Dehls brought to the new enterprise an extensive business experience in this country, in addition to 10 years in the import and export business in Central America. Dr. Leo Stone received his chemical training at the University of Berlin under Emil Fischer, in addition working under Adolf von Baeyer at Munich and later under Marston T. Bogert at Columbia University. The happy combination of Dehls the businessman and Stone the chemist provided the new concern with executive personnel with a wealth of experience in their respective fields.

Benzol Products Co. commenced operations at 13 Margaretta St. with the manufacture of cinchophen and neocinchophen. These products were distributed by the sales agency of Edward S. Burke & Co., a relationship which continues to the present day. Later, in 1933, further sales distribution was undertaken by F. L. Bodman of Philadelphia, an arrangement also still in effect. The Company's first efforts met with such success that larger manufacturing space was required. A search for such production facilities disclosed that a chemical manufacturing plant on 10 acres of land along the Raritan River in Piscataway, N. J., belonging to the Granton Chemical Co. was available. This property was accordingly purchased by Dehls & Stein in 1927 and leased to Benzol Products Co. The same year Joseph Ebert resigned and Dr. Herbert C. Oehlers became plant manager.

In 1929 Trygve Holmsen came to the Company as director of research, and one [illegible] first accomplishments was to perfect a process for the manufacture of [illegible] yellow and white, which subsequently became one of the growing

concern's major products. With cinchophen, neocinchophen, and phenolphthalein continuing to provide the bulk of the business, the Research Department devoted itself to the development of new products. These years of activity, 1926-30, bore fruit with the introduction in 1930 of phenobarbital, sodium phenobarbital, and procaine; in 1931, benzocaine, 8-hydroxyquinoline and its derivatives.

In 1932 Frederick Dehls, who joined the concern in 1926, was elected secretary and became a director. In the meantime Benzol Products Co. operated as a corporation until Dec. 1933, when its assets were acquired by Dehls & Stein. From 1933-38 it functioned as a partnership, being a division of Dehls & Stein. A new corporation, once again called Benzol Products Co., took over operations on Jan. 1, 1938, and Dr. Leo Stone again became president, Frederick Dehls vice-president, John C. Dehls treasurer, and Frederick Stone, who joined the Company in 1931, secretary. These officers constituted the board of directors.

During these corporate changes the Research and Development Departments were not idle. To the list of pharmaceuticals were added theophylline, aminophyllin, aminoacetic acid, and chlorobutanol. Branching out from purely medicinal products, the Company was now manufacturing such aromatic and flavoring chemicals as benzaldehyde, methyl cinnamate, diacetyl, cinnamic acid, phenylacetic acid, and bromostyrol. During this active period of expansion, James B. Zimmerman became plant manager, replacing Dr. Oehlers, who died in 1937. Dr. Adolph Zimmerli was engaged as consultant and from the date of his first association with the Company, still retained, he has been responsible for important improvements in processes as well as the development of many new products.

The officers remained unchanged until Mar. 1940, when Donald C. Stone became assistant secretary and Robert Dehls, vice-president. Jan. 1, 1941, Benzol Products Co. purchased the Piscataway plant from Dehls & Stein and in May of that year Donald Stone became secretary upon the death of Frederick C. Stone; Cecil Stone was elected assistant secretary. In 1944 Donald Stone went overseas with the Army Transport Service and Robert Dehls was elected secretary, Stone becoming vice-president. From 1944-46, the board of directors has been composed of: Dr. Leo Stone, president; Frederick Dehls and Donald C. Stone, vice-presidents; John C. Dehls, treasurer; Robert Dehls, secretary.

During the war years nonessential chemicals were reduced to a minimum to devote the entire production of the plant to the war effort. Although taxed to capacity, harassed by the shortage of skilled help, and in many instances utilizing equipment which under normal conditions would have long since been replaced, the Company maintained peak production of pharmaceuticals to fill its government obligations. With the advent of peace Benzol Products has set about carrying out a carefully conceived plan of judicious expansion, never losing sight of its original policy to produce fine chemicals of the highest attainable quality.

BINNEY & SMITH COMPANY began as a partnership in 1882. In Jan. 1860, C. Harold Smith was born in London. In 1864 his American uncle, Joseph Binney, started the Peekskill Chemical Works at Annsville, N. Y., in the Hudson River Valley, for the grinding, packaging, and distribution of charcoal. Somewhat later he began manufacturing lampblack and for a time hauled his product, and also the raw material, over the hilly roads to the Peekskill station. In 1880 Joseph Binney set up headquarters in New York and was joined by his son and nephew. Two years later C. Harold Smith and Edwin Binney, son of Joseph, established the partnership of Binney & Smith, and in 1902 incorporated as Binney & Smith Co. The first office was a single room up one flight of stairs at 17 Platt St., N. Y. City.

Natural gas was first being developed in Pennsylvania and Binney and Smith

both took an active part pioneering the production of the new carbon black from natural gas. Once man discovered the principle of making lampblack he burned practically every substance he could lay his hands on in the effort to make the best possible black. However, the first distinct improvement in many centuries came just at the time the Binney & Smith partnership was formed. Natural gas was discovered in the United States as early as the Revolutionary period, in all probability while drilling for water. The first practical use of it occurred in 1824 in the town of Fredonia, N. Y., where it furnished illumination for the fete in honor of General Lafayette. For many years illumination was its only use.

The first carbon black from natural gas was made in Ohio about 1879. Not much progress was made until the discovery, the following year, of the tremendous natural gas deposits in Pennsylvania. Here it came booming to the surface along with petroleum from the new Pennsylvania oil fields. The oil men considered gas a nuisance, allowing it to blow off into the air and wishing it would stop altogether. Finally one oil operator, a man named Drew, more enterprising than the others, built a so-called "smut mine" to convert this waste gas into carbon. Binney & Smith undertook the sale of Drew's unique new product, starting on a line which has been continuously followed for more than 60 years.

Also in 1880 the Peerless Carbon Black Co. was established for the first production of ink blacks of the long or flow type, and in due course Binney & Smith arranged to distribute Peerless black. The introduction of this carbon of colloidal fineness closely followed William Talbot's discovery of the photoengraving process, and Frederick Ives' development of the half-tone screen. The intrinsic characteristics of such pigment supplied the needed medium. Inks as previously formulated were unsuited for printing from plates so finely etched, but the long flow, high tinctorial strength, and fine texture of Peerless black provided the solution.

During 1900 arrangements were made for a supply of North Carolina talc and a grist mill near Easton, Pa., was taken over with cheap water power. There was a slate quarry near by, and talc and slate were ground and combined with cement to produce slate pencils. Easton is still the Company's manufacturing headquarters, and this operation is continuing to grow and now includes a diversified line of products. Slate pencils were only the beginning and chalk was soon considered, since it was recognized that the crayon of that day was far from satisfactory. Through use of a formula containing whiting, Binney & Smith developed An-Du-Septic, white dustless blackboard crayon, in 1902. This product made a good clean mark on the schoolroom blackboard. Similarly, the colored crayons which school children were forced to use were no better than the hard white chalk which had been the only material formerly available. By this time the Company had started making black wax crayons for marking shipping crates and for other commercial applications. New ways of toughening wax had been discovered and a high-quality carbon black was used. The next question considered was whether a complete line of good-quality colored wax crayons could be put out at a price which school children could afford. Edwin Binney developed such a process in 1903, and two generations of American children have used Crayolas to express themselves on paper.

Since the development of Crayola, Binney & Smith Co. has worked in every way possible to make the benefits of color available to more people. Children with deficient eyesight had had difficulty with blackboard writing, but by adding a special yellow pigment to white chalk Binney & Smith developed a product through which the eyestrain of thousands of children has been eased. There was also a demand for water colors as good as Crayolas and the Artista line was developed. Artista [illegible] paints followed a few years later. More recently Shaw finger paints have

been added. Originally developed to give school children a new color medium, these have also proved helpful in the convalescent treatment of psychoneurotic war veterans.

Until 1910 there was no particular change of note in the general uses of carbon black. Its production and consumption had grown along with the industries of the country, but its use was confined principally to printing inks, paints, polishes, and dark paper. During 1910 an event took place in England that revolutionized not only carbon black itself, but rubber compounding. That year the first tire was made in which cord construction was utilized in the carcass. To distinguish this new type from those made with the ordinary woven fabric carcass, its maker desired to darken the tread of the new tire. Inquiry was made at the Binney & Smith London office as to a black of greatest tinctorial strength, since it was desired to use the least possible amount of carbon to accomplish the results. Binney & Smith #40 black was recommended, and a small percentage was introduced into the tread stock of the new cord tire.

In 1912 the B. F. Goodrich Co. secured American rights for Silvertown cord tires and proceeded to manufacture them in this country. In testing out the tires from England it was noted that their tread was tougher and provided greater resistance to abrasion than the white zinc oxide tread stocks regularly used at that time. Investigation of the cause of the improved quality brought out that the only difference consisted of the modest addition of #40 carbon black. At the request of Goodrich, tests were begun with higher proportions of #40 black, with the result that the quality improvement became more marked as the percentages were increased. This resulted in arrangements for furnishing a large quantity of carbon black sufficient to take care of the Goodrich requirements, and they at once embarked on the promotion of black tread tires. As these tires very quickly proved their superiority the use of carbon black was adopted throughout the rubber industry, and the black treads, in conjunction with the improved cord carcass, soon provided the motorist with a 20-25,000-mile tire compared to the 3-5,000-mile tire he had had formerly.

Adoption of carbon black by rubber manufacturers demanded a volume never before handled, and necessitated sizable increases in manufacturing capacity. Up until that time production had been carried on chiefly by small individual operating companies in Pennsylvania and West Virginia for whom Binney & Smith acted as distributors. For better administration it was evident that a strong and well-equipped organization should be created for the production of the new requirements, and both Edwin Binney and C. Harold Smith were instrumental with their friends and associates among producing companies in the formation of the first Columbian Carbon Co., a West Virginia corporation. Due to close association with the companies entering this combination, Binney & Smith handled distribution for the new corporation and has continued to do so.

As the rubber business grew and as the use of carbon black was extended to many compounds besides tires, expert technical guidance was required in the distribution and servicing of the various carbons. Accordingly, the first research and development department in the carbon black industry was started by the Company in 1924, and has since been expanded to include all phases of research, development, and service work in connection with the rubber, ink, protective coatings, and plastics industries. From this work have flowed several contributions of outstanding interest and importance.

Although carbon black is handled by the ink and paint manufacturers without trouble, this is due to the fact that the processing of their products involves the mixing of the carbon with oils, varnishes, and other liquid media, hence without

dusting difficulties. On the other hand, rubber manufacturers met difficulties since many had to mix black in dry form on open mills. Various remedies were tried. Mills were hooded and the black made compact by means of compression, but the trouble still continued. Those using enclosed mixers were harassed with the dust encountered in charging such machines. While the carbon was being dispersed on roller mills, great clouds of dust would be thrown into the air to the discomfort of the operating personnel and to the damage of near-by materials. Solution to the problem came in 1927 when the first pelleted or dustless black was introduced, and on which the Wiegand-Venuto patents were granted in 1932. Now called Micronex Beads, this black not only solved the dirt problem, but also made it possible to ship black in bulk in hopper cars, and to handle it at rubber manufacturing plants by bulk conveying systems.

Binney & Smith Co. also became associated with the Magnetic Pigment Co. and cooperated in establishing a plant at Alexandria, Va., in 1911, for making iron oxide pigments from a precipitation process developed by Dr. Peter Fireman. In 1914 a new modern plant for these colors was erected at Trenton, N. J., and the first black synthetic oxide of iron produced. In 1929 Magnetic Pigment was taken by Columbian Carbon, Binney & Smith Co. continuing as distributors.

Another result of research was the production of carbon black dispersions. To the aqueous dispersions first produced were later added dispersions of high-color carbons in nitrocellulose and other bases, which have been patented. These dispersions now cover a broad field, including oil, aqueous, and resin bases, and are proving valuable to manufacturers of special products who cannot use dry pigments to full advantage.

C. Harold Smith died in 1931 and Edwin Binney in 1934. The organization has continued since that time with S. Vere Smith as chairman of the board and Allan F. Kitchel, president. To plant facilities at Easton manufacturing crayons and other school materials, has been added a plant in Los Angeles to take care of the needs of the Pacific Coast.

In the lines where Binney & Smith act as distributors, Columbian Carbon Co. has greatly increased its manufacturing facilities which now embrace the complete line of channel and furnace carbons of all qualities, as well as iron oxides and bone blacks. Binney & Smith also distributes fatty acids and other derivatives to the rubber trade for the W. C. Hardesty Co., and sells for other manufacturers in this country. In the export field it represents a number of important industries, extensively distributing their products. Headquarters are in New York and offices are operated in Akron, Philadelphia, Chicago, and Boston. In Canada, Great Britain, France, and Denmark wholly owned or associated companies maintain offices. In all other large consuming centers, both in the United States and in other countries of the world, Binney & Smith Co. has direct representatives.

HENRY BOWER CHEMICAL MANUFACTURING COMPANY had its real beginning in 1858, when Henry Bower designed and erected his first manufacturing enterprise, a plant to produce sulfate of ammonia from the condenser and washer liquors then running to waste from the Philadelphia Gas Works. Financial assistance was readily forthcoming from the users of his product, who were anxious to be relieved of the many uncertainties inherent in importations. At the suggestion of his uncle, George D. Rosengarten, manufacturer of pharmaceutical chemicals, he accepted a position as a drug clerk in 1852. As a student at the Philadelphia College of Pharmacy from which he graduated in 1856, he received fundamental training in chemistry. After graduation, he acquired commercial [illegible] in his chosen field as a merchant and importer of domestic and foreign

chemicals. The conversion of waste materials into useful commodities always absorbed his interest and indeed the present business stems from that basic idea.

The original plant was located at the Philadelphia Gas Works, but before the end of the year a portion of the present site was leased for $15 per month and the by-product ammonia liquors brought there for processing. Having been raised on a farm, Bower's thoughts soon turned to fertilizers as an outlet for his expanding production. The domestic demand for fertilizers was then insufficient to support even this small production of ammonium sulfate, so the greater part was exported. In 1866 Bower advertised a "complete manure containing superphosphate of lime, ammonia, and potash." However, the fertilizer venture lasted only 10 years. About that time the aqua ammonia industry was expanding in and near Philadelphia and it soon became the principal outlet for Bower's ammonium sulfate.

Again the utilization of wastes brought forth a new product, founding another important industry. By 1860 Bower had finally succeeded in producing a "pure inodorous glycerin" believed to be the first made in this country. The effluent from stearin candle works was recovered in many cities of the East and Middle West and shipped to Philadelphia for treatment. Transformation of an evil-smelling, high-priced material into a glycerin with no odor at a fraction of the former cost attracted users never before hoped for. In recognition of this accomplishment the Franklin Institute awarded Henry Bower the Elliott Cresson medal in 1878. During all these early years, the founder had personally handled research, development, production, and sales. Expansion of the enterprise required able assistance so the services of an Englishman, James Kenyon, experienced in the manufacture of sulfuric acid and sulfate of ammonia, were engaged and the production of acid commenced.

The name of Henry Bower has been associated with prussiates since 1867. In those days production of yellow prussiate of potash depended on waste leather scrap and waste hoofs and horns as a source of cyanogen and carbonate of potash recovered from leached wood ashes. Later, German carbonate of potash provided a cheaper source of that salt, and in 1880 cyanogen was recovered as another by-product of the Philadelphia Gas Works. This process, the washing of the gas stream with a solution of copperas in water, with refinements, is in use today both in this country and abroad. William L. Rowland, having just received his degree as chemist from the University of Pennsylvania, joined the Company in 1881 and assisted in the improvement of this process. He was also instrumental in developing a process which produced a concentrated ammonia liquor through the distillation and condensation of weak gasworks ammonia liquors. By raising the ammonia content to 15% it became possible to ship greater distances and tankcars were employed. Gasworks in New England and as far away as Atlanta and Birmingham thus became sources of raw materials.

In 1882 Henry Bower joined with Henry Pemberton, a former president of the Pennsylvania Salt Manufacturing Co. and Harrison Bros. & Co., paint manufacturers, to form the Kalion Chemical Co. to manufacture bichromate of potash. The process suggested by Pemberton was not successful and he thereupon withdrew. The company continued in operation, utilizing the accepted process of the day, and in 1892 the Harrison interests were purchased by Bower.

The firm of Henry Bower & Son was formed shortly after the entry of George R. Bower and William H. Bower into the business in 1885 and 1886, respectively. The first two sons of Henry Bower had completed their education at the University of Pennsylvania, William as a chemist and George as a graduate of the school of liberal arts. This partnership was short-lived as the depression of 1887 found it in an overextended position as a result of which the business failed. Friends quickly

rallied to the support of Henry Bower, and largely through trust and confidence placed in him by William Weightman, head of Powers & Weightman, pharmaceutical chemists, financial aid was forthcoming with which the business was reorganized. With these funds every creditor was paid in full with interest and some years later the heirs of Weightman received their final check for principal and interest.

In 1887 the business formerly conducted by Henry Bower & Son was taken over and operated by the Ammonia Co. of Philadelphia, while the Kalion Chemical Co. continued its operations. During 1894 the manufacture of aqua ammonia was commenced by the Ammonia Co. to care for the pharmaceutical trade. This product was in increasing demand from the near-by production of ammonia alum by Charles Lennig and later the Solvay plant at Syracuse, N. Y., whose first ammonia requirements for the manufacture of soda ash were purchased from Henry Bower. The business continued under Henry Bower until 1896, when at the age of 63 he passed away. The responsibilties fell to sons William and George, who a year previous had been joined by the third and youngest son, Frank B. Bower. He had also graduated from the University of Pennsylvania, as a mechanical engineer. A fourth member of the family, Sydney Thayer, who had married Henry Bower's only daughter, joined the executive staff in 1890. Thus the two companies, founded by Henry Bower, entered the new century with son George as president, William and Frank, vice-presidents, and Sydney Thayer, secretary-treasurer.

In 1891 a process for the manufacture of tin tetrachloride was purchased from a Belgian named Lambotte on the basis of which a plant was built on the Ammonia Co.'s property. Its operations began in 1893 and continued until 1914 when due to World War I, tin prices had so increased economic operations became impossible. Believed to be the first chlorine plant operated in the United States, its maximum capacity in 1893 was 3,000 lb. per day.

In 1902, as a result of price wars in the bichromate industry, the Baltimore Chrome Works, owned by Jesse Tyson and founded in 1845 by Isaac Tyson, was offered for sale. William Weightman offered to loan the necessary funds. After acquiring that company the entire production of bichromates was transferred to Baltimore. Under its new management this company prospered until 1908, when it was merged with two other companies to form the Mutual Chemical Co. of America. Members of the Bower family retired from active management, retaining their stock ownership and positions on the board of directors of the new company.

The Ammonia Co. of Philadelphia, mainly interested in the production of aqua ammonia by a process developed by William Rowland and William Bower in 1894, branched out into anhydrous ammonia in 1903. At about that time the Delaware Chemical Co. of Wilmington, owned by the Krebs and Warner families of that city, was absorbed in a merger, forming the National Ammonia Co. Louis Werliin, a Dane who had been superintendent of the Delaware concern, offered his services to the Ammonia Co. Under his direction a plant was designed and built to produce anhydrous ammonia from aqua ammonia.

In 1906, to simplify the transaction of business, the Ammonia Co., Kalion Chemical Co., and the Baltimore Chrome Works were merged into the Henry Bower Chemical Manufacturing Co., with George R. Bower, president, William H. Bower, 1st vice-president, Frank B. Bower, 2d vice-president, and Sydney Thayer, secretary-treasurer. After disposal of the Baltimore property in 1908, the manufacture of aqua and anhydrous ammonia and yellow prussiate of potash was continued until the outbreak of World War I. The British blockade of potash from Germany was a serious blow to the prussiate operations. However, through the ingenuity of William H. Bower, assisted by Samuel F. Grove, a process to produce [illegible] from prussiate of soda and sulfate of ammonia was developed in the

Company's laboratories, and turned over to the pigment trade without royalties. To the present day the soda salt is used almost exclusively in the production of Prussian blues.

For many years Henry Bower and his sons had competed actively with the old firm of Carter & Scattergood in the sale of prussiate of potash. However, in 1911 Carter & Scattergood fell upon evil days and offered to sell their business to the Bower interests. The offer was accepted, the good will and equipment being transferred to the Bower's plant on Gray's Ferry Road. In 1834 Carter & Scattergood had purchased the business of John and Daniel Elliott, founded in 1754 by their father, John Elliott, who was the great grandfather of Lucretia E. Bower, wife of Henry Bower. In 1834 the first yellow prussiate of potash produced in this country had been manufactured in the old Elliott factory which returned to the direct descendants of its founder 157 years later.

Manufacture of calcium ferrocyanide was commenced in 1916 to supplant importations cut off from Germany. It found a ready market in the citric, tartaric, and lactic acid industries for removal of small traces of objectionable metals.

In 1919 George R. Bower died and was succeeded as president by William H. Bower. Frank B. Bower became 1st vice-president and William L. Rowland, 2d vice-president, Sydney Thayer continuing as secretary-treasurer. Thayer died in 1932 whereupon his duties were assumed by his son, Sydney Thayer, Jr., who had joined the business in 1921. Frank B. Bower resigned in 1928 and was succeeded as vice-president by Henry Bower, the son of George R. Bower, who originally came to the Company in 1917. Rowland passed away in 1929 and his son, Edmund Rowland, who had entered the business in 1924, became assistant-secretary. No further changes occurred until the resignation of William H. Bower as president in 1940. He was succeeded by Henry Bower. Sydney Thayer, Jr., then became 1st vice-president and treasurer and Edmund Rowland, 2d vice-president and secretary.

The Company has continued keeping close to its special lines of aqua and anhydrous ammonia, yellow prussiate of soda, and calcium ferrocyanide up to the present year (1947), 89 years after its founding.

BURROUGHS WELLCOME & CO. (U.S.A.) INC. was incorporated in New York in 1924. It is the largest overseas division of the organization originally established as Burroughs Wellcome & Co., in England, Sept. 1, 1880. While incorporated in the United States, the shares are wholly owned by the Wellcome Foundation Ltd., a private limited liability company registered in England the same year, 1924.

The founders of Burroughs Wellcome & Co. were both native Americans and American-trained. Henry Wellcome was born in Almond, a small frontier settlement in Wisconsin, in 1853. While still a boy, his family moved to Minnesota and at 13 he was helping his father in a drugstore which the latter had acquired from a brother, Dr. Jacob W. B. Wellcome. In 1870 Henry Wellcome took a position with retail pharmacists in Rochester, Minn., where he came under the influence of Dr. William W. Mayo, father of the Mayo Clinic founders. Two years later he arrived in Chicago when the city was emerging from the ruins of the Great Fire, where he engaged in the retail drug field. He matriculated at the Chicago College of Pharmacy in 1872 and transferred next year to the Philadelphia College of Pharmacy, graduating in 1874. The same year he went with Caswell Hazard & Co., retail pharmacists, at 24th St. and Broadway, N. Y. City, then generally regarded as the leading pharmacy in the country.

Silas M. Burroughs was born in Medina, N. Y., in 1846. At an early age he

entered the retail drug business at Lockport, N. Y. He attended the Philadelphia College of Pharmacy and was graduated in 1877, his thesis being on *The Compression of Medicinal Powders.* While in Philadelphia, he became salesman for John Wyeth & Bro. and in 1877 went to London to establish an agency for Wyeth preparations. In 1880 he was joined in London by Henry S. Wellcome, who brought with him the exclusive agency, for all countries except the United States, for the McKesson & Robbins new line of gelatin-coated pills, and they established the business of Burroughs Wellcome & Co.

The idea of compressed drugs was not entirely new in England, for William Brockedon as far back as 1842 had compressed chemicals and galenicals and secured a British patent for the process. But at the time that Burroughs Wellcome & Co. of London introduced compressed medicines and other new and improved American pharmaceuticals, the opportunities were unique because medicine in Britain was still marking time in loyalty to an antiquated faith in big bottles, large doses, and nauseous drugs. The introduction of Wyeth's compressed pills and McKesson & Robbins' gelatin-coated pills soon met with great favor.

An important factor in the success of compressed medicines was the modern methods of introducing them to the medical profession. Burroughs Wellcome & Co. was the only house in the United Kingdom which made a business of calling on the doctor with samples of new things. Another departure from contemporary practice was in advertising in the medical and trade journals. Instead of the usual full-page insertion, Burroughs Wellcome at this period ordinarily used 10-20 pages in a single issue of a journal, and on special occasions, 20-30 pages. The advantages of the new products were so great as to create an ever-increasing demand. Specializing in featuring various American products as improvements in pharmacy, Burroughs Wellcome & Co. soon became known in London as the "Yankee Chemists."

The production of preparations of the Company's own manufacture increased to the point where it became necessary to give up most of the agencies for products manufactured by other firms. In connection with this new trend Wellcome invented and introduced the new word Tabloid, destined to become a most celebrated medical trade-mark to denote "Fine Products issued by Burroughs Wellcome & Co." Eventually the Company became successor to Brockedon, inventor of compressed medicines. Subsequent expansion and development led to the distribution of its products all over the world through branch houses in Australia, Canada, United States, Africa, India, China, and South America, and special depots in various countries.

The New York branch was established in 1906, when the sales agency for the Company's products in the United States held by Fairchild Bros. & Foster in New York for more than 25 years, was terminated. Thomas Moore served as New York manager, 1906-11, when he was succeeded by Thomas Nevin, previously manager of the Montreal branch. In 1906 some light manufacturing was done but separate manufacturing laboratories were established in New York in 1908. In 1925 the manufacturing was transferred to a new and modern plant on a 10-acre site in Tuckahoe, N. Y. The Experimental Research Laboratories, now known as the Wellcome Research Laboratories, were established there in 1928. They consist, at present, of Divisions of Pharmacology, Organic Chemistry, Biological Chemistry, and an adequate research library. There are also Development Laboratories and Control Laboratories at Tuckahoe.

On the death of Silas M. Burroughs in 1895, Henry S. Wellcome became the sole proprietor of the world-wide business of Burroughs Wellcome & Co. which continued as an American enterprise until 1910, when Wellcome was naturalized a British subject. Always interested in research, Wellcome established a series

of research laboratories in England which have had an enviable reputation for their contributions both to scientific knowledge and practical therapeutics. These include the Wellcome Laboratories of Tropical Medicine in London, the Wellcome Physiological Research Laboratories and the Wellcome Chemical Research Laboratories in Beckenham, Kent, the Wellcome Entomological Field Laboratories at Esher, Surrey, and the Wellcome Veterinary Research Station at Frant in Sussex. The Wellcome Historical Medical Museum and the Wellcome Museum of Medical Science, both in London, are regarded as models of their kind.

The Wellcome Physiological Research Laboratories, established in 1894, produced antidiphtheritic serum and had supplies in distribution before the end of the year. The first antidiphtheritic serum used in the United States was supplied by these laboratories. During the early days and until the real value of antidiphtheritic serum was conclusively demonstrated, all that could be produced was gratuitously placed at the disposal of principal clinics, hospitals, and private physicians.

Wellcome was a life member of the American Pharmaceutical Association from 1875 and always took an active interest in its scientific work. During the last 15 years of his life he spent much time in Washington, personally participating in the campaign for the establishment of a national headquarters building for the Association there. He was present at the exercises in 1934 when the Washington building was dedicated as the American Institute of Pharmacy. At that time he was honorary president of the Association which bestowed the Remington honor medal upon him for his scientific and other valuable contributions to pharmacy.

During his later years Henry S. Wellcome was showered with honors from various governments, universities, and learned societies. The honorary degree of Doctor of Laws was conferred upon him by the University of Edinburgh in 1928. In recognition of his life's work and generous support of medical research, he was knighted by King George V in 1932 and the same year was elected an Honorary Fellow of the Royal College of Surgeons of England and a Fellow of the Royal Society. In 1934 the President of France personally conferred on Wellcome the Croix de Chevalier de la Legion d'Honneur, the Royal African Society awarded him its gold medal, and he received the honorary degree of Doctor of Science from Marquette University, Wisconsin. He was again honored by France in 1936, being awarded the Croix d'Officier de la Legion d'Honneur, and in the same year received from the Spanish Republic the decoration of Comendador de la Orden de la Republica. In 1924 he consolidated his many interests in England, America, and elsewhere—research laboratories, medical museums and libraries, development and manufacturing laboratories, distributing companies, and organizations—in the Wellcome Foundation Ltd., in London. All the shares of the Foundation are vested in five trustees and managed by a board of directors. The aims of the Foundation and its various units are directed to one ultimate purpose only, namely, assisting the prevention, alleviation, and cure of disease. Whether in terms of Foundation basic research or of new and improved medicinal products derived from research or of monies paid by the Foundation to the Wellcome trustees for use in still further research, humanity is the cause benefited. The Foundation thus is a notable example of a private enterprise whose divisible profits are permanently dedicated to the advancement of knowledge for the general benefit of mankind. Its incidental constitution as a Limited Company should not be allowed to obscure this main fact. Within the ambit of the Wellcome Foundation is found an association of academic and industrial research activities that has enabled a quite unusual variety and wealth of research contacts to be developed between it and various academic institutions and societies on the one hand, and with many types of industrial bodies on the other.

On the death of Sir Henry Wellcome in 1936, Thomas Nevin became president and general manager of the New York corporation, which positions he resigned in 1944 but continued as vice-chairman of the board until Feb. 1945, when he retired after 33 years' service as New York general manager and a total service of over 39 years with the Company. Sept. 1, 1944, Guy S. Dunbar, formerly director of sales and vice-president in charge of distribution, was elected president and general manager. After service with the Company for 32 years, Dunbar resigned at the end of 1945. At present the officers of the New York corporation are William N. Creasy, president and general manager; Howard B. Fonda, senior vice-president in charge of production; Earl W. Rigg, vice-president and manager of distribution; R. C. Ralphs, vice-president and treasurer; William F. Dowling, Jr., secretary.

GODFREY L. CABOT, INC., had its beginnings in 1882 when Dr. Godfrey Lowell Cabot joined his brother, Samuel Cabot, in the manufacture of carbon black at Worthington, Pa. At that time carbon black or "gas black," as it was called, was a new material developed as a pigment superior to lampblack in printing inks. It represented an innovation in the conservation of natural gas which was being wasted on an increasing scale. Godfrey Cabot brought to the new enterprise a technical knowledge acquired through study at Harvard, where he was graduated *magna cum laude*, at M.I.T., Zurich Politechnicum, and other institutions. Five years later, 1887, he bought his brother's interest in the business of which he is still president. Since 1920, Thomas D. Cabot, his son, has actively engaged in the business and is vice-president and treasurer.

It has been said that Dr. Cabot was the first to approach the manufacture of carbon black from the chemist's point of view. His training and technically resourceful attitude toward an infant industry quickly resulted in new methods, new products, and new applications of these products. His scientific papers and patents also trace the story of these developments. The Bureau of Mines Bulletin No. 192 (*Carbon Black—Its Manufacture, Properties, and Uses*, by R. O. Neal and G. St. J. Perrott, 1922) says: "In 1883 G. L. Cabot made some laboratory experiments concerning the effect on the yield of enriching gas by gasoline vapors. He found that by passing preheated gas over gasoline the carbon black recovery was increased by 11% of the weight of the gasoline used." The Bulletin quotes Dr. Cabot: "The first factory that I ever owned, at Worthington, Pa., was originally built in the year 1882, and carried water on the surface to keep the temperature down to the boiling point. We subsequently got much better yields without water cooling. Later on I tried the experiment of sprinkling the surface continuously with a lawn sprinkler device, and here again I immediately cut down the yield." This plant was the first at which efforts were made to confine and economize the gas. Another innovation at Worthington in 1883 was the development of a burner tip which became known throughout the industry as the "Cabot" tip. Early manufacturers used lava tips, similar to those then in use for domestic lighting, but Cabot developed a larger size, more suitable for burning gas for carbon black.

The above Bulletin also gives a full description of the "plate" or Cabot process: "The plate system was invented by G. L. Cabot about 1892 and has two modifications. One method employs stationary plates 24 ft. in diameter having beneath them revolving scrapers and burners; another method uses revolving plates 24 ft. in diameter with stationary scrapers and burners. The first arrangement is the more widely used and is employed at a plant in West Virginia having until recently the [illegible] output of any factory in the world." The Cabot plant at Grantsville, W. Va.,

referred to above, was built in 1899 and maintained its position as the largest carbon black plant in the world until it was closed down in 1919.

A year after Dr. Cabot had patented his "plate" process, he was issued another patent (U. S. 491,923, Feb. 14, 1893) covering a process for heating gas, enriching it with vapors of liquid hydrocarbons, and delivering the hot mixture to the burners. This process was adopted by German and Czech manufacturers in the late 1930's.

Two further patents were taken out by Dr. Cabot in 1915: U. S. Pat. 1,140,250 involved a system for the transportation of liquefied petroleum gases by barges and boats. The possibility of using this means of transport has been reconsidered only recently. U. S. Pat. 1,162,131 was for a process to manufacture carbon black by impinging flames on rotating rollers and removing the black by stationary scrapers. The method was used successfully for many years, and is still employed for some blacks for lithographic inks.

1929-32, two patents were issued to W. A. Duerr, a progressive carbon black plant designer of the Cabot Co. Duerr was responsible for the first use of electric welding for plant construction and for the design of a cantilever form of table construction, using 12 channels. He also introduced a by-passed gas governor to improve the uniformity of gas flow; the first use of a pasted package instead of a tied sack; the first use of electric drive and unit drive with elimination of power machinery; a plant layout with central packing house for more than one unit; and an electric indicator to insure uniform densification of black by agitation. The first patent issued to Duerr dealt with a method of separating grit from carbon black by air flotation; three years later, he helped develop a pneumatic separator for the same purpose. Perhaps his most important patent was for a machine to compress carbon black.

Meanwhile U. S. Pat. 1,780,231 had been issued, Nov. 4, 1930, to cover the nigrometer developed by the Cabot Co. in collaboration with Dr. Arthur C. Hardy of M.I.T. It is a device for measuring blackness by the degree of light reflected from a slide containing a smear of carbon black in linseed oil. The blackness or "scale," is indicated on a calibrated arm by means of a movable needle, which establishes the reading. The nigrometer is in wide use throughout all industries using carbon black, and its findings are accepted as the standard gauge of intensity of blackness. Particle size and other physical properties have been effectively correlated with the nigrometer scale. In 1935 E. H. Damon patented a process greatly improving the blackness of carbon blacks by controlled oxidation. This method is still commonly used in the manufacture of high-quality carbon black for ink, lacquer, and enamel.

Further technological improvements were represented in six patents issued 1935-43 to Edmund Billings and Harold H. Offutt. They cover a dry process for the conversion of carbon black and other finely divided particles into dustless, free-flowing granules, a discovery that caused a minor revolution in the industry. This invention made possible dustless flow handling of carbon black and immediately led to the shipment of Cabot "Spheron" in covered hopper cars to consumers equipped with bulk-handling apparatus. Today over half the carbon black produced is shipped in bulk.

F. H. Amon, the Company's technical director, perfected in 1938 a process for manufacturing dry process pellets of carbon for use as a darkening agent in Portland cement and mortars. Carbon black made by this process is used chiefly to prevent glare on highways and airplane runways. Offutt devised a method by which carbon black pellets treated in an electrical furnace are converted into a form of graphite. This product and also a later modification were adapted for use in dry

cell and flashlight batteries. In 1943, Dr. W. R. Smith and Owen J. Brown, Jr., brought out a technique for treating carbon black granules in such a way as to convert them into activated carbon suitable for gas masks and for clarification of sugar sirups and other absorptive products.

Amon's most important contribution is for a shield placed around the flame used in the manufacture of channel black. Shielded tips increase the quantity of black recovered more than any other improvement in the last 20 years and are now being used outside the Cabot Co.

Born of wartime necessity, synthetic rubber demanded new rubber-compounding ingredients. The industry greatly increased its production of the so-called soft or furnace blacks. Cabot built large installations at Ville Platte, La., and Guymon, Okla., giving an annual maximum furnace production capacity in excess of 150,000,000 lb. In 1945 Cabot acquired the General Atlas Carbon Co., pioneer producers of furnace black, and a separate corporation of the same name was formed to operate and expand the furnace capacity. Cabot has also participated in the two most outstanding recent developments in the furnace black field, the development of highly reinforcing grades of furnace black and the bulk shipment of furnace black. The capacity of the Cabot-General Atlas combination is about 50-50 channel and furnace black.

Much research done outside the Company is conducted under endowments made by Godfrey L. Cabot. Fellowships endowed by him over the past 10 years include four grants to Massachusetts Institute of Technology. One of these was for X-ray diffraction study of the structure of carbon black by Prof. B. E. Warren. Another was for study of small-angle X-ray scattering. A third was for an investigation of carbon black and its reinforcement of rubber by means of the electron microscope, to Prof. F. O. Schmitt of the Department of Biology, and the fourth was granted to the Department of Building, Engineering & Construction for a study of the properties of finely divided material prepared by grinding, under Prof. H. S. Staley. Prof. Paul H. Emmett and Johns Hopkins University received a grant for determination of surface areas and surface properties of carbon black. Cabot also sponsored a study of surface activity by heats of adsorption at Amherst College; of electrical conductivity of carbon black in inks at Brooklyn Polytechnic Institute; and of effect of carbon black on soil temperature at Massachusetts State College. Cabot has also endowed studies at Harvard, M.I.T., and Northeastern for studies of solar energy and its utilization. Research undertaken by the Cabot Co. established the structure of carbon black, methods of particle size and surface area measurement, and surface activity.

Cabot was the first to introduce graded (by rubber test) series of channel blacks; a full line of special blacks for inks, lacquers, enamels, lithographic inks, and plastics; development of conductive channel blacks; several new furnace blacks (such as Sterling 99 and 105); new processes for furnace blacks. It was officially cited for developing in wartime a dry cell battery black.

Godfrey L. Cabot, Inc., of Boston is the parent of the Cabot group. The subsidiary companies are Cabot Carbon Co., Retort Chemical Division of the Cabot Carbon Co., General Atlas Carbon Co., Wak Co., Cabot Gas Corp., Cabot Shops, Inc., Valley Vitamins, Inc., and 50% of Texas Elf Carbon Co.

Godfrey L. Cabot, Inc., operates through subsidiary companies in the production of carbon black, natural gas and gasoline, pine distillates, and alfalfa extracts. It also produces oil and manufactures pumping equipment. The industries served are rubber, ink, paint, varnish, enamel, lacquer, plastics, soap, fertilizer, and manufacturers using naval stores. Sales activities are conducted by the parent company which has sales representatives throughout the world.

CARBORUNDUM COMPANY had its first chapter written with the first man-made abrasive, outstanding among the great scientific contributions during the past 50 years. In Mar. 1891, at Monongahela City, Pa., Edward Goodrich Acheson produced in a tiny electric furnace, fashioned from an iron bowl, a few strange crystals—hard, sharp, diamond-like—which eventually proved to be silicon carbide and which were destined to revolutionize grinding and grinding methods. An interesting description of this experiment is to be found in Dr. Acheson's autobiography, *A Pathfinder*. To this hitherto unknown compound Dr. Acheson applied the trade-mark Carborundum, which today is the registered trade-mark of the Carborundum Co.

The first market the intrepid and hopeful inventor approached was the gem-polishing and cutting trade, to which he offered his new abrasive as a substitute for diamond dust, for the rough polishing of gems. The "Carborundum" was such a worthy substitute that it brought a price of 40¢ per carat or $880 per lb. With an improved furnace based on the incandescent principle, Acheson began producing his product in larger quantities. He then began selling the crushed, graded crystals to mechanics who mixed the abrasive with oil or grease and used it for seating steam valves where it did the work better and faster than emery or other natural abrasives previously used. Later Acheson mixed the grains with bonding agents and hand-fashioned tiny wheels which he sold to dentists for the preparation of cavities and other dental work.

But far more important, the first man-made abrasive opened a new era in industry. Previously, grinding wheels made from emery and corundum were used as mere tool sharpeners. No one even dreamed of the grinding wheel becoming the great production tool that it is today.

On Sept. 28, 1891, Dr. Acheson incorporated the Carborundum Co. in Pennsylvania, with himself the first president; John S. Huyler, vice-president; Joseph W. Marsh, treasurer; and William C. McAllister, secretary. The little company managed to make considerable progress. Watchmakers began using the new abrasive for forming and finishing watch jewels, the sales of dental wheels increased, and its use for grinding in brass cocks, valves, etc., seemed to flourish, as did its substitution for diamond dust in rough polishing of gems. An early prospectus of the Company alluded to other possible uses and markets such as the optical trade, the use of larger wheels in the industrial field, and in the coating of paper and cloth. It noted that in 1892 the famed scientist Nicola Tesla was experimenting with silicon carbide crystals as light-giving bodies in electric lamps.

In 1895 the great hydraulic power project at Niagara Falls had been completed and Acheson and his associates decided to move there, build a much bigger plant and larger improved furnaces for big-scale production. A small plant was opened in October. Meanwhile Dr. Acheson engaged a budding young engineer, the late Dr. Frank J. Tone, and a consultant electrochemist, Francis A. J. Fitzgerald, and the little company signed the second contract for power in the history of the Niagara Falls Power Co. The first had been signed by the Pittsburgh Reduction Co., forerunner of the Aluminum Co. of America.

In practically all of their research Acheson, Tone, and Fitzgerald had no precedents to go by. Their plant was their laboratory. They had to devise and improve electric-furnace practice, and they are credited with being the first to apply 1,000 hp. to an electrothermic process. They developed various types of bonding agents used in the manufacture of grinding wheels and suitable kilns in which these wheels were vitrified. The story of their patient research, their successes and failures can truly be regarded as an industrial romance.

Soon after the opening of the Niagara Falls plant, the Mellon interests, represented by Richard B. and Andrew W. Mellon, invested capital in the organization. This early and sustained financial interest and the wise counsel and untiring efforts of the Mellons, who long served as members of early boards of directors, played a great part in the development and the ultimate success of the Company. In Mar. 1899 the late Frank W. Haskell was made a director, representing the Mellons, and in July 1901, he succeeded Dr. Acheson as president. Serving with Haskell at that time were George R. Rayner, secretary; Frank H. Manley, treasurer; with Tone as works manager.

The discovery of silicon carbide stimulated research in other abrasives. In 1899 Charles B. Jacobs invented a process for the manufacture of crystalline alumina or manufactured corundum by the fusion of bauxite in the electric furnace. In 1909, as the result of extensive research by Dr. Tone and his associates, the Company began manufacturing and selling it under the trade-mark Aloxite. Equally important was the development of super-refractories. It was chiefly Dr. Tone's efforts and subsequent research that resulted in these refractories having wide application in many industries where high temperatures are encountered.

The story of the Carborundum Co. and its competitors in abrasive manufacturing parallels the story of American industry. The abrasive industry grew along with the foundry, the steel, the automotive, the plastics, the aviation, and the chemical and process industries, because abrasives and refractories are vitally necessary in all industry. One of the first achievements of the Niagara Falls plant was the production of coarse-grit grinding wheels for the snagging of castings in the foundry trade. Soon thereafter, a gradual broadening of uses and applications established the grinding wheel as a great production tool. Later came grinding wheels particularly adapted to specific jobs, making possible higher production and greater precision. It can truly be said that the progress made in grinding is largely responsible for the mass production of duplicate precision parts throughout industry.

The development of abrasive paper and cloth for the finishing of metals, woods, leathers, and other materials, and the steady increase of the applications and uses for super-refractories, have added interesting and important chapters to the history of the Carborundum Co. The Niagara Falls plant expanded with the increased demand for its products until today it covers more than 50 acres and has an operating floor space of more than 2,000,000 sq. ft. In 1947 an 18 million dollar modernization program was launched to provide new and improved facilities for all the main divisions of the Company.

Further growth of the Company came in 1913 when a subsidiary, the Carborundum Co., Ltd., was established and a plant for the manufacture of grinding wheels and other abrasive products was built at Manchester, England. Later a refractories product plant was added there. Other subsidiaries include Canadian Carborundum Co., Ltd., established in 1919 at Niagara Falls, Ont., with an extensive furnace plant for the production of Aloxite and the fabrication of abrasive products and refractories; one of the largest furnace plants in the world for silicon carbide located at Shawinigan Falls, Quebec, built in 1917; and the Deutsche Carborundum Werke, with a plant at Düsseldorf, Germany, which was opened in 1912. Carborundum Co. purchased Didier-March Co. buildings at Perth Amboy, N. J., in 1920, and reconverted to a modern plant for super-refractories. Here is located the Refractories Division.

Sept. 1927 the Company purchased the Globar Co. of Milwaukee and moved the plant to Niagara Falls as the Globar Division. Today this division is one of the leading manufacturers of nonmetallic electric-heating elements for use in high-

temperature furnaces and kilns and also for the manufacture of many types of resistors used in radar and electrical circuits. The Carborundum Co. also has participating investments in Australian Abrasives Pty. at Sydney and the abrasive furnace plant, Arendal Smeltverke, at Eydhavn, Norway.

Following the death of Frank W. Haskell, Frank J. Tone was named president and director in Apr. 1919. Associated with Dr. Tone since 1898 as general sales manager, George R. Rayner became a director next year, and vice-president from Apr. 1919 until his death in Aug. 1938. Another official of long service was Frank H. Manley, who joined in 1896, was appointed treasurer in 1899, named director in 1921, retired in 1942, and died in Oct. 1946.

In Apr. 1942, Dr. Tone was named chairman of the board and was succeeded as president by Arthur Batts, with the organization since 1901. From junior clerk, Batts worked his way up to assistant to the treasurer, secretary in 1927, and a director in 1938. In 1947, three years after Dr. Tone's death, he was elected chairman of the board and was succeeded as president by Harry K. Clark. Clark has long been identified with the abrasive and refractory industry, having been vice-president and general manager of the Norton Co. of Worcester, Mass., with which he was connected for 27 years. In Sept. 1940, he had joined the Advisory Committee for Defense and later the Office of Production Management. He was commissioned in the Navy and assigned to the Army and Navy Munitions Board. He later established the Emergency Plant Operations Division and had under his operation supervision of 104 plants. After the war Clark came out of retirement to join Carborundum, first as vice-president in charge of operations and then as president. As vice-president he was succeeded by Edwin R. Broden, formerly connected with Blaw-Knox Co.

Research, from the very beginning of the Company, has played a most important part in its progress and development. It has made possible not only the improvements in established products, but has been the means of developing many new products and extending the uses and applications for abrasives and refractories. Harry C. Martin is technical director and Charles E. Woodell, manager of research and development. Among plans for plant extension at Niagara Falls is the establishment of a most modern research center.

Headed by Frank J. Tone, Jr., vice-president and general sales manager, the Company maintains a sales staff of well over 200 representatives and engineers. In important industrial centers here and in Canada are located branch sales offices and warehouses, and there is a further distribution of Carborundum products through approximately 250 distributors. The present officers are: Arthur Batts, chairman; Harry K. Clark, president; Edwin R. Broden, Henry P. Kirchner, and Frank J. Tone, Jr., vice-presidents; Edward A. Montgomery, secretary; Austin W. Clark, treasurer-controller; and Anthony J. D'Arcangelo and Gilbert J. Stewart, assistant treasurers. The directors are Batts, Broden, H. K. and A. W. Clark, Tone, Jr., and George W. Wyckoff.

CARUS CHEMICAL COMPANY exemplifies a chemical enterprise of moderate size which by specializing has created for itself a definite niche in the industry. It grew out of the suggestion of a chemical purchasing agent in the early days of World War I to Dr. Edward H. Carus, who in the summer of 1915 resigned his position as instructor of chemistry at the University of Kansas to return to his home at LaSalle, Ill., where he was seeking some chemical activity. In college he had produced potassium permanganate in the laboratory, but he little anticipated the difficulties confronting factory production of this salt which till then had not been made commonly in the United States. Imported potassium

muriate from Germany was off the market, so working with potash leached from wood ashes in Wisconsin and Michigan, a process was worked out which produced permanganate of only 28% $KMnO_4$, due to the sulfate contained in the ash extract. This necessitated production of refined caustic potash as the first step and by the time the process was perfected in all its details the price of potassium permanganate had risen to $4 per pound. Had there been price ceilings at that time, the entire venture would have been commercially unfeasible.

The Carus Chemical Co. was incorporated in Illinois, Feb. 3, 1919, by Edward H. Carus, Karl Gruenwald, Leslie Graper, Paul Knop, and Oscar W. Hoberg. All employees of the Company were given the opportunity to subscribe to the stock issue, and there were actually 30 original shareholders, including the Company stenographer, Norine Jenkins, and the bookkeeper, Edward Fratcher. At this time the Company produced potassium permanganate and saccharin. At the present time (1947) it makes potassium permanganate, hydroquinone, and, as required, special batches of rare permanganates such as calcium, sodium, zinc, manganese, barium, besides manganese sulfate and precipitated manganese.

CASEIN COMPANY OF AMERICA, now the Chemical Division of Borden's, started in Bellows Falls, Vt., when William A. Hall developed a sizable business in casein cold-water powdered paints and casein as an adhesive in making coated papers, and incorporated it in Mar. 1900. Included in the assets was the plant in Bellows Falls and a number of patents relating to casein and its uses. One Hall patent, owned by the Lactroid Co., was for making casein plastics. This antedated the Galalith casein plastics patent by some years. Hall also held a patent for making casein paint and covering the use of casein with formaldehyde for making insoluble paper coatings such as are now universally used by the coating mills.

For some years most of the Casein Co.'s efforts were directed toward the introduction of casein in the paper coatings field and improvements in making casein cold-water paint. New methods had to be introduced. Inexperience and plain inertia, combined with nonuniformity of product, made the change-over from animal glue to casein a slow and difficult one. Few paper mills employed chemists. The Casein Co. of America did have chemists, and they worked long hours trying to solve the problems of their customers. They had another job, that was instructing the creameries, their source of supply, how to prepare crude casein from skim milk. Much of the damage to casein use was done in the creameries, for faulty separation meant nonuniform, burned, dirty, high-acid casein.

Meanwhile the Company formed agencies in England, France, Italy, and Germany, and was shipping a substantial tonnage of casein abroad. New fields were found for utilizing casein in other industries. Product quality was greatly improved. New physical characteristics were developed which aided in expanding uses for casein in leather finishing, production of oilcloth, calico printing, cloth sizing, and as a food. The next big step was the production of the first good, cold-water-soluble, water-resistant wood glue. This took place in 1916-17 and was first used for the construction of planes for World War I.

In 1928 the Borden Co. embarked upon its policy of diversification. Its origin was a patent issued Aug. 19, 1856, that was the seed of not only a great company, but a great industry. This patent had been granted after three years of hard struggle, and two distinguished scientists, Robert McFarlane and John H. Currie, had checked and backed the applicant's claims. That applicant was Gail Borden. The patent covered the process of condensing milk "in vacuo." Borden secured the backing of Jeremiah Milbank, banker, and the first successful factory for making

condensed milk began operations. For many years the company Borden founded was interested solely in milk. First condensed milk; then evaporated milk; later fluid milk. Finally it began acquiring several companies in allied businesses that used dairy by-products or provided essential raw material sources. In 1929 Borden's acquired the Casein Co. which included the National Milk Sugar Co.

Although the uses of casein continued to expand, interest turned to adhesives based on synthetic resins. Specifically, interest was focused on the urea-formaldehyde type which was assuming importance in Germany. William F. Leicester, now a vice-president of Borden's, completed negotiations with I.G. Farbenindustrie in 1936 for a license under its patents. Production of urea-resin adhesives was begun in 1937. That same year the licensing agreement was abrogated due to failure of the licensor to protect against patent infringement.

In 1940 the Casein Co. began the production of a phenol-formaldehyde adhesive. In 1942 it developed a resorcinol-formaldehyde adhesive in connection with the production of wooden airplanes for World War II. In 1947 the Company acquired Durite Plastics, Inc., producers of phenol-furfural and phenol-formaldehyde resins. In addition to the Durite plant in Philadelphia, the Chemical Division of the Borden Co. has four plants. There is a general adhesives plant at Bainbridge, N. Y., and one in Seattle, Wash. At Kernersville, N. C., formaldehyde resins for use in furniture manufacture are produced, and in Springfield, Ore., there is a plant for the production of formaldehyde by the direct oxidation of methanol.

CATALIN CORPORATION OF AMERICA started as a secret-process venture to duplicate a beautiful new plastic material being made in Germany. In 1926 Nathan Loth, importer of nitrocellulose combs from Germany, told his friend Carl A. Holstein of a foreign cast phenolic resin that could be produced in a wide range of colors of great depth and transparency and easily machined. Holstein and some of his associates arranged for Loth and a young lawyer, R. C. Rand, to go to Germany and check into the situation.

Loth and Rand found very limited and secret operations being carried on by the Herold Corp. of Hamburg, with which a tentative contract was signed, based on a showing of products only. They brought back to New York samples quite different from anything then on the market, and in Jan. 1927, American Catalin Corp. was incorporated in New York with an authorized capital of $120,000 preferred stock and 13,000 shares of common. A German chemist familiar with the process was engaged to start up operations at College Point, Long Island. Holstein was chairman of the board of the new company; Loth, president; C. W. Allen, vice-president; and Rand, a director. Soon after, Wesley Thompson, now technical director, joined the Company to organize a permanent chemical policy.

The next three or four years was one continuous struggle. The new product was expensive, its quality far from the present-day standards of cast resins, and an entirely new market had to be created for it. Furthermore, competition arose as soon as the enterprise began to be successful. As there were no patents, some of the employees left to form new, competing corporations. Attempts to enjoin these operations on the ground of breach of contract of secrecy could not be enforced.

Early in 1929 certain of the stockholders, wanting to concentrate control before undertaking further financing, incorporated the Catalin Corp. of America with Charles Deller, president; Fred T. Hepburn, vice-president; and Robert Frese, treasurer. The new company acquired over 50% of the operating company's stock and made loans to it. Soon thereafter William Theile acquired the stock of Holstein and Allen and was elected director of both companies. Oct. 1, 1931, he was elected president of American Catalin Corp. and assumed control. About this time

Harry Krehbiel joined the Company to take charge of sales and the plant was moved from College Point to its present location at Fords, N. J., where it operates under a lease from Heyden Chemical Corp., its principal supplier of formaldehyde. Catalin Corp. of America acquired all the stock in the original company by 1932, when it became the operating company and the subsidiary was retained until 1946 as a sales company. In 1932 Theile became president of Catalin and Lawrence Iverson, vice-president in charge of production.

In 1930 it was rumored that patents on the original Herold process were being obtained both in Europe and in the United States by Pollopas, Ltd., of England which owned the patent rights of Dr. Pollak of Vienna and his associates. The Company authorized another 100,000 shares of stock and in Feb. 1933 purchased U. S. Pats. 1,854,600 and 1,858,168 and corresponding Canadian patents. It then started suit against the Marblette Corp., which did not come to trial, for Marblette and Joanite Corp. took licenses. Sales improved, the Company was showing a profit, and during Mar. 1934 its stock was fully listed on the New York Curb Exchange.

However, unlicensed competition was not over. The Catalazuli Manufacturing Co., which first operated on a very small scale but later obtained financial backing from one of its customers, was sued for infringement of U. S. Pat. 1,854,600, in June 1934. Both the District Court and the Circuit Court of Appeals ruled that Catalin's patent was valid and infringed. Subsequently licenses were taken by du Pont Co., Fiberloid Corp., Bakelite Corp., and A. E. Knoedler Co. After some years du Pont and Monsanto surrendered their licenses and gave up the manufacture of cast phenolic resins.

This successful litigation and the Company's increased profits were reflected in the stock appraisal, which rose from a low point of 25¢ a share in 1931 to over \$16 in 1936. Many of the original backers disposed of their holdings and the Company's stock became widely scattered, but Theile and his close friend Degnon, who had been a director since July 1931, retained their stock and working control

While the Company did not grow as rapidly as the stock market anticipated, it continued to increase the sales of its cast product, the "Gem of Plastics," and to investigate new products of more general commercial application, particularly liquid phenol resins and polystyrene. This research turned out to be the Company's salvation, for when the war came, appearance items had very little consideration but the liquid resins were in great demand. As soon as the shortage of phenol became threatening, the Company bought an old tar acid plant and with secondhand equipment converted it to phenol manufacture. For many months it was largely the phenol from this source which kept the Company alive. Eventually wartime uses were also found for the cast resin.

Upon president Theile's sudden death in Feb. 1944, the Company was operated by Krehbiel, active vice-president; Leo Beck, vice-president of American Catalin; and Alan Mann, patent counsel and vice-president since Apr. 1939, following the death of Iverson in 1938. In Sept. 1944 Mann was elected chairman; Krehbiel, president; and Beck, vice-president, with Frese continuing as secretary-treasurer. Eventually Theile's stock was all sold on the open market so that the present board of directors represents widely scattered, small stockholders.

When the war ended the Company faced very few conversion problems. Steps were taken to eliminate bottlenecks on the cast-resin side so that over-all production could be increased, and to start a more efficient unit for liquid resins.

CELANESE CORPORATION OF AMERICA presented the cellulose acetate yarn Celanese to the public in 1925. However, before Celanese made its bow, its inventors, Dr. Camille Dreyfus and his late brother, Dr. Henry Dreyfus, had to struggle long and arduously to bring their yarn on the market. Hundreds upon hundreds of tests were made in pursuit of their goal to produce a fine gossamer-like filament from cellulose acetate.

Then World War I intervened, and cellulose acetate became a vital ingredient of airplane "dope." At the request of the British Government the Dreyfus brothers halted their experiments on yarn and went to England to erect a factory for the production of cellulose acetate for the Air Forces. When America got into the fight, Dr. Camille Dreyfus was invited to construct a similar plant at Cumberland, Md. For this purpose the American Cellulose & Chemical Manufacturing Co., Ltd., was incorporated in Delaware. However, the war ended before the American plant was completed.

With the cessation of hostilities there ceased, too, the wartime necessity of cellulose acetate. But research and development continued and in 1925 commercial production of the new textile fiber began in the Cumberland plant. The distinctive and desirable characteristics of Celanese gave fabrics woven and knitted from it many remarkably improved qualities. Fabrics made of all-Celanese yarns when washed or wet showed only a modicum of shrinkage in contrast to other fabrics. Celanese absorbed less moisture than other yarns and was superior to any other fiber as an insulator.

But, like anything new or revolutionary, the value of Celanese had to be proven. The Company began to teach the textile industry the most efficacious means of weaving, knitting, dyeing, and finishing this new product. By 1927 Celanese yarns and fabrics were cutting an important figure in the textile industry. It was then that the corporate title was changed to Celanese Corp. of America.

In rapid succession there followed a series of developments in the yarn and fabric fields under the Company's leadership: the technique of cross-dyeing—a standard operation today; the introduction of a permanent moire which could be washed, dry-cleaned, or even immersed in sea water without affecting its moire markings; the first ninon made of a synthetic yarn; the first high-count satin; the first sharkskin; and numerous other innovations. Celanese gave the entire textile industry an intravenous injection of enterprise and ingenuity.

Meanwhile, the Cumberland plant was being taxed to meet the demands of the textile trade. Extensions and improvements of plant facilities were made but even record expenditures failed to satisfy the public demand. In 1932 Celanese Corp. acquired weaving mills at New London, Conn., and a year later a second purchase was made at Williamsport, Pa.

In 1934 the Corporation issued its first license to a shirt manufacturer to use the newly developed Lamicel fabric for wrinkle-free collars. That year it began producing ribbons from full-width Celanese fabrics through the utilization of the thermoplasticity of cellulose acetate, and introduced Celanese black yarn, which was yarn born black in the spinning solution.

In 1939 conditions were propitious for proceeding with a long-conceived expansion program, the major point of which was the start of construction on a second yarn-producing plant at Narrows, Va., and from which shipments were made the next year. Properties at New London were sold and weaving operations transferred to Staunton, Va. Buildings were acquired at Burlington, N. C., for spinning staple fiber into yarn, an operation in which only Celanese Corp., among the yarn producers, is engaged. Before America entered the war, the Company was

carrying on experiments with Fortisan, the world's strongest yarn, which proved to be one of the textile industry's major contributions to the winning of the conflict.

The year 1945 was an active one for the Corporation, for it marked the addition of several new properties. At Summit, N. J., a building was acquired for the centralization of research in cellulosic chemistry; at Bridgewater, Va., construction work was begun on a completely modern plant for the manufacture of knitted fabrics; and at Rock Hill, S. C., a plantsite was acquired for the erection of a new plant for the production of acetate filament yarns. Celanese yarn is sold to mills throughout the country and woven or knitted into a great variety of fabrics which are sold to manufacturers and retail stores. Fabrics made with continuous filament yarns are sold principally in the fields where other rayons and silks are used, while those made with staple fiber are sold principally in the fields where wool and mixtures of wool and cotton are used. The staple fiber production of the American synthetic yarn industry has grown from 12,300,000 lb. in 1936 to 228,400,000 lb. in 1947.

Celanese Corp. was a pioneer in the cellulose acetate field and today accounts for more than half of all the acetate yarn produced in the United States. In 1946, however, the Corporation entered the viscose rayon field through its absorption of the Tubize Rayon Corp. Tubize was also a pioneer, representing the consolidation and merger of Tubize Artificial Silk Co., incorporated in 1920, and American Chatillon Corp., incorporated in 1928. The former company constructed the first and only nitrocellulose yarn-producing plant in this country. As a consequence of the absorption of Tubize Rayon Corp., the Company acquired two other large plants. One, located at Rome, Ga., is engaged principally in the manufacture of continuous filament rayon yarns made by both the viscose and acetate process. The Hopewell, Va., plant produces knitted fabrics and dyes and finishes both knitted and woven fabrics.

Explorations in the cellulose acetate field provided Celanese Corp. with much valuable information as to the plastics potentialities of this material. In 1927 the Corporation acquired the controlling interest in Celluloid Corp., the first plastics company in the United States and owner of the famous trade-mark Celluloid. In 1941 Celluloid Corp. was merged into Celanese Corp. and is now operated as the Plastics Division, with its manufacturing plant at Newark, N. J. A second plastics-producing plant is operating at Belvidere, N. J.

During the war years the Plastics Division developed and produced plastics for the combined war effort. Shortly after the war, Celanese introduced on the market the first postwar plastic, Forticel, a compound of cellulose and propionic acid, which has opened up new fields of application because of its great toughness and brilliancy of finish. Other Celanese plastic and related products include films, sheets, rods, tubes, molding powder, and transparent packaging material. Among its more prominent registered trade-marks in plastics are Celluloid, Lumarith, Vimlite, Celcon, and Lumapane.

The triumvirate of textiles, plastics, and chemicals was effectively completed around the middle of 1945 when Celanese began at Bishop, Tex., the first large-scale production of certain chemicals from natural gases. This represented the result of many years of research by Company chemists and chemical engineers. Celanese is now able to produce chemicals necessary in the manufacture of its textile and plastic products, as well as certain other products. In addition, the Company has a petroleum chemical research center at Clarkwood, Tex. Emphasis is placed on the development of derivatives of the Company's primary organic products and improvement of current plant processes.

Confronted with the growing world shortage of cellulose, the Corporation in

1947 made plans for production of a substantial part of its own increased requirements. Arrangements were made with the Government of British Columbia for a forest management license for cutting rights to large tracts of forest which will provide the timber requirements for a pulp plant for the production of high alpha cellulose on Watson Island, near Prince Rupert, B.C. Columbia Cellulose Co., Ltd., wholly-owned Canadian subsidiary of Celanese Corp., operates the pulp plant.

In association with Mexican interests the Celanese Corp. of America has formed two producing companies in Mexico for the manufacture of both cellulose acetate and viscose process yarns.

CHAMPION PAPER AND FIBRE COMPANY had its inception in a desire to produce coated papers of improved quality for printing purposes. Its founder, Peter G. Thomson of Cincinnati, who had considerable experience in the handling and printing characteristics of coated paper, incorporated the Champion Coated Paper Co. in Hamilton, O., Nov. 2, 1893. Operations began in 1894, paper stock being purchased from the Sterling Paper Co. of Hamilton and coating applied by the new concern. To provide a more sustained supply of paper for the expanding business, the Eagle Paper Co. of Franklin, O., was purchased in 1897. Next year, in an effort to control the quality and source of the raw materials, a mill was built in St. Charles, Ill., to produce casein, the adhesive used for coating paper.

The coating mill at Hamilton was destroyed by fire on Dec. 22, 1901. It was rebuilt promptly and a paper mill was constructed in 1902 adjacent to it. This parent mill has operated since then as one of the foremost producers of coated paper. The only serious interruption came as a result of a combined flood and fire in 1913. Again the mill was rebuilt promptly and resumed operations the following year.

After 1902 the Company rapidly expanded and plans for a pulp mill were projected. Reversing the usual trend, Thomson turned southward to the virgin forests of western North Carolina which also offered the inducements of short freight haul and stable labor conditions. Sulfite pulp production from coniferous wood was begun in Jan. 1908. Since Apr. 1908, when pulping of hardwoods by the soda process was undertaken, utilization of Southern hardwoods for papermaking has continued without interruption. From 1910-19 Southern pine was pulped by the soda process and since then by the sulfate process at the Canton mill, operated since its inception as the Champion Fibre Co., under Reuben B. Robertson. Improved multistage bleaching procedures involving direct chlorination were installed in 1935 for the bleaching of the pine sulfate or kraft pulp.

For a number of years, the Canton mill produced simultaneously soda, sulfate, sulfite, and mechanical pulps. The requirements of pulp for various grades of paper, together with economic and other considerations, led to certain changes in pulp processing. The groundwood operation installed in 1931 was discontinued in 1937, the soda process for pulping hardwoods was discontinued in 1938 in favor of the sulfate process, and the sulfite pulp production was converted to the sulfate process early in 1947. The manufacture of paper was begun at Canton in 1922 where facilities for uncoated paper and paperboard were steadily increased until they surpassed 500 tons daily in early 1947.

Another mill producing bleached pine sulfate pulp was projected in the South in 1935, when a site just east of Houston, Tex., was selected because of its strategic location with respect to fuel gas, salt, lime, wood, and water transportation. As plans went forward in 1936, the corporate name was changed to the Champion Paper & Fibre Co., and the three mills became known as the Hamilton, Canton, and Houston Divisions. Production of bleached pine sulfate pulp at

Houston began in Jan. 1937. In 1940 part of the pulp production was diverted to a new paper machine designed to make machine-coated magazine paper. At present (1947) paper production at Houston is being expanded and diversified.

The Champion organization thus consists of three mills producing paper, of which two produce pulp. The general policy has been towards mass production of white papers, both coated and uncoated. Very little kraft or unbleached paper is manufactured. The three units employ 6,800 and produce over 2,000,000 lb. of various grades of coated papers, as well as tablet, bond, envelope, postal card, and food-container papers. District sales offices are maintained in New York, Philadelphia, Chicago, Detroit, Cincinnati, Atlanta, St. Louis, and San Francisco.

As regards chemicals, attention has been given primarily to the basic raw materials. To insure adequate supplies of cellulose, conservation and woodland-purchase programs are followed actively. Deposits of clay and lime are operated at Sandersville, Ga., and near Knoxville, Tenn. The electrolytic manufacture of chlorine was begun in 1916, and today approximately 60 tons are produced daily. Originally Wheeler cells were installed to be followed by Champion cells in 1924, and Hooker cells in 1937.

By-product chemicals have likewise occupied a position of considerable importance in the Company history. Chestnut extract tannin has been produced since 1908, and today 5,000,000 lb. per month are produced, making this the largest single chestnut extract unit operating in the world. As a by-product of the electrolytic chlorine production, about 65 tons of caustic soda are produced daily, practically all of which is marketed as 50% solution. Compressed hydrogen gas at the Houston Division is another by-product of this operation. Champion was one of the pioneers in by-product tall oil and turpentine from the sulfate-pulping process. The processing of turpentine was begun in 1922 and today approximately 1,000 gal. of refined product are recovered daily. Tall oil production was begun in 1929 and now amounts to about 25 tons daily.

A subsidiary, Hamilton Laboratories, produces and markets industrial and pharmaceutical grades of organic mercury compounds. Another subsidiary, So-Hy Products Corp., produces sodium hypochlorite for domestic consumption.

In addition to chemical control laboratories at each of the three mills, research laboratories were established at Hamilton and at Canton in 1926 and 1928, respectively. These have been concerned with research and development in fibrous raw materials, chemical raw materials for the pulp mill, adhesives and pigments for the coating operations, recovery and processing of by-products, recovery of process chemicals, pulping and bleaching processes, and coating operations, including machine-coating and cast-coating. Fellowships have been maintained in the past at Mellon Institute, and currently the Company is a supporting member of the Institute of Paper Chemistry.

The Company founder, Peter G. Thomson, continued as president until his death in 1931, when he was succeeded by his son. Alexander. Another son, Logan G., became president in 1935, Alexander Thomson becoming chairman of the board, in which capacity he served until his death in 1939. Reuben B. Robertson was first president of the Champion Fibre Co. unit, and then named executive vice-president of the Champion Paper & Fibre Co. in 1936. He became president of the Company upon the death of Logan G. Thomson in 1936. Other present officers include: Reuben B. Roberston, Jr., executive vice-president, manufacturing; Herbert T. Randall, vice-president, engineering; Dwight Thomson, vice-president, industrial relations; Herbert Suter, vice-president, sales; John Osborne, W. M. Benzing, and Clarke Marion, vice-presidents; Scott Zoller, treasurer; and W. J. Damtoft, assistant treasurer.

CHEMICAL FOUNDATION is remembered for two accomplishments: the emancipation of the American organic chemical industry from foreign domination after World War I, and its extensive educational program for the benefit of the American chemical industry. The Foundation was organized Feb. 1919 upon the executive orders of President Wilson, primarily to make available to American manufacturers the chemical processes and products covered by enemy-owned (mostly German) patents and to assist in upbuilding an independent chemical industry. These patents were taken out in this country not to promote the development of our chemical industry but to prevent such development.

Prior to World War I the German chemical industry had almost a world monopoly in the organic chemical field. Foreign competition was eliminated by patent protection, supplemented by bribery, price cutting, and full-line forcing. Our chemical dependence upon Germany and the machinations used in this country by German officials and agents were revealed by Francis P. Garvan as director of the Bureau of Investigation of the Alien Property Custodian. Garvan was chosen because of qualities he demonstrated while assistant district attorney of N. Y. City. He was astounded at the throttlehold the Germans had on our chemical industry and conceived the idea of the Chemical Foundation, not only to administer the patents for the greater benefit of the industry, but also to protect the infant organic chemical industry. President Wilson and A. Mitchell Palmer, Alien Property Custodian, gave wholehearted support to the Foundation, and knowing Garvan's vigorous, able leadership, Palmer directed that he be elected president in order that its broad patriotic objectives might be fulfilled.

The specific purposes of the Foundation were to issue nonexclusive licenses under its patents to all American persons or corporations upon fair and equal terms with the intention of building up a competitive chemical industry, to foster the development of this industry by widespread educational means, and to encourage scientific research. The voting common and preferred stock was purchased by both corporations and individuals who would be directly or indirectly affected by the use of the patents. (For complete list of the original stockholders, see Vol. III, pp. 482-83.)

In 17 assignments the Alien Property Custodian conveyed to the Foundation a total of 4,764 patents, 283 patent applications (of which 196 matured into patents), 874 trade-marks, 492 copyrights, and 56 prewar contracts. The total amount paid to the Government was $269,850. The patents were the most valuable of all these properties. They pertained to products, processes, and apparatus in all the branches of the chemical industry. Some patents and patent applications were assigned to the Foundation in error, the reason being that they had previously been assigned to American companies or were not enemy-owned. Hence the Foundation reassigned 61 patents and four patent applications in this category.

The availability of licenses was extensively publicized. A complete list of the patents as well as specialized lists grouped according to subjects were printed and distributed. A 40,000-card index was prepared and used for promptly answering inquiries for patents on specified subjects. The main royalty-bearing patents covered dyes, drugs, stainless steel, synthetic ammonia and methanol, apparatus, and various chemicals. A royalty-free license was given to the U. S. Government on all the properties transferred to the Foundation by the Alien Property Custodian. How important this licensing program was to the development of an independent American chemical industry is evident from the facts set forth in the volumes of the History covering the period 1912-22. Among its licensees have been many of the well-known names in industry, but at the same time small companies and even

individuals obtained licenses under identically the same terms. (A complete list will be found in Volume III, pp. 498-505.) Licensees complained continually that the patent specifications did not give complete information and know-how for manufacturing purposes. The meagerness of patent information was apparently also part of the German plan to prevent manufacture abroad. The royalty rates generally were set at 5% or less of the net selling price for product patents and somewhat lower for process patents, the specific rate for each patent or group of patents in one license being set after negotiation with the licensee. The royalty rate and other provisions to several licensees under the same patent or group of patents were always the same.

During 1919-46, the total income of the Foundation was approximately $8,600,000, of which 72% was contributed to scientific research and educational work. Of this income, $1,900,000 was spent for research and education work in the field of chemistry in relation to medicine, $1,200,000 in relation to agriculture, $250,000 in relation to industry, and $1,070,000 for the promotion of chemical education and scientific periodicals. No individual or corporation ever benefited financially from this income and no stockholder of the Foundation ever received any dividend. The bylaws provided that the president and vice-president receive no salary; this provision was strictly adhered to.

Medicine was regarded as the most important field in which chemistry could be applied to great advantage for everyone. Soon after the Foundation was organized nine leading scientists were requested to draft a report on the best plan to achieve progress of American medicine in the age of chemistry. Its conclusion was that cooperative scientific endeavor—biologist, pathologist, bacteriologist, pharmacologist, physicist, and chemist—should be used in the attack on medical problems if rapid advances were to be made in the conquering of diseases. Over 700,000 copies of this 82-page report were distributed far and wide. Contributions for medical research, amounting to 22% of the total income of the Foundation, were made to many universities, hospitals, and organizations. Studies were made on many of the well-known and lesser-known diseases, stressing particularly the application of chemistry in the solution of the problems. Cancer, the common cold, tuberculosis, children's diseases, general chemomedical research, biological stains, and diabetes are just a few of these fields. One of its research men, Dr. Perrin H. Long of Johns Hopkins, introduced sulfanilamide into the United States and performed the original research work in this country on the medical application of this drug. The Foundation was instrumental in having Congress establish the National Institute of Health as the central laboratory of the Federal Government where cooperative research could be undertaken on medical problems. The Foundation contributed the first $100,000 to its maintenance.

In agriculture, the Foundation supported a wide variety of research. The fundamental purpose was the application of chemistry to show how agricultural products could be used in industry. Research was conducted on hemp, sweet potato starch, soybeans, tung oil, power alcohol, cellulose, etc. All expenses of the National Farm Chemurgic Council during its first two years were paid by the Foundation. The research of Dr. Charles H. Herty, proving that newsprint can be made from Southern pine, was paid for by the Foundation. It was apparent that the creation of this new industry would be important to the whole country, especially the South. A result of this research was the establishment of a commercial plant at Lufkin, Tex., where newsprint has been made successfully since 1940. Garvan insisted that there be no patents on this research and that neither he nor the Foundation would have any personal interest in it except the benefit to the American people.

The Foundation felt that it was most important to create public opinion favor-

ing the necessity of the development of an independent American chemical industry, for peace as well as for war. Accordingly, early in its history it distributed to educators, legislators, members of clubs, editors, industrialists, and others, many popularly written authoritative books and articles dealing with chemistry. Such books as *Creative Chemistry*, *Chemistry in Industry*, *Chemistry in Agriculture*, *Chemistry in Medicine*, *Power Alcohol and Farm Relief* (of the Deserted Village Series), *The Farm Chemurgic*, and *Men, Money and Molecules*, helped make the country conscious of the vital importance of chemistry in industry, health, and national defense. The Foundation distributed 174 different pieces of literature. Of some only a few hundred copies were mailed; of others, hundreds of thousands. In addition, some of our foremost chemists and others gave popular talks before clubs and chambers of commerce on the importance of chemistry for the future welfare of this country.

In 1923 the Garvans instituted an annual prize essay contest open to all high school and college students, conducted under the sponsorship of the American Chemical Society. The annual prizes were six 4-year university scholarships with all expenses paid for high school students, and money awards for college students, in addition to cash prizes and books. These contests were conducted for eight years during which 5,000,000 students wrote essays on the relation of chemistry to health, enrichment of life, agriculture, national defense, the home, and development of industry. Not only the students but also their parents and others thus became acquainted with the importance of chemistry in their daily lives. The Foundation paid the administrative expenses of the contests and contributed a specially selected set of books to each high school and public library in the country.

One purpose of this educational program was the promotion of new chemical enterprises. These required trained chemists. Therefore, the Foundation established a Chair of Chemical Education at Johns Hopkins, endowed fellowships in several universities, contributed promotional booklets for a number of universities to enlarge their laboratories, paid the expenses of several summer schools of chemistry and engineering teachers, and paid the deficits for several years of the *Journal of Chemical Education* (for teachers) and *The Chemistry Leaflet* (for students).

An important development to which the Foundation contributed was the cyclotron. Dr. Ernest O. Lawrence conceived the fundamental principle of this method of bombarding the atom in 1929. Experimentation with small apparatus demonstrated the workability of the idea. In Aug. 1931 the Research Corp. and the Chemical Foundation jointly began their contributions to Dr. Lawrence's Radiation Laboratory at the University of California for the large-scale development of the cyclotron.

Following World War I, the Germans determined to recapture their profitable American market. Dr. Krell, director of Badische told Dr. Herty, during his visit in Ludwigshafen in 1919: "We are going to get back our business in your country." Knowing that the chemical war was on, Garvan at Congressional hearings pleaded for protection until the new industry could get on its feet. An embargo or license import control had been placed on the importation of all coal-tar products. An emergency tariff bill, providing for a continuation of this control, was passed by Congress and was effective until the passage of the regular tariff bill in 1922, in which coal-tar chemicals were protected by rates given to no other industry.

In the summer of 1922 Thomas W. Miller, Alien Property Custodian, acting upon the direction of President Harding, demanded the return to the U. S. Government of all the patents and other property which the Foundation had purchased. The Foundation declined to comply with the demand and the Government then

entered suit. The trial lasted seven weeks and 13 volumes of testimony and exhibits were taken. Jan. 3, 1924, District Court Judge Morris rendered his opinion in which he found no ground upon which the sale of enemy property to the Foundation could be set aside and so dismissed the bill of complaint. In his 60-page opinion, the Judge said: "The devotion of the property to the public use stands not upon written documents alone. It has a deeper foundation—the property is in the keeping of men who have in its management no selfish interest to serve and whose devotion to the public interest has been established. No better plan for devoting the property to the public use has been suggested. The plan has stood the most severe of all tests—actual trial. The defendant has kept the faith." The case was appealed to the Circuit Court of Appeals and the Supreme Court, both of which affirmed Judge Morris' opinion.

In 1925 the Germans exported synthetic methanol to this country at a little more than half the price of natural wood alcohol. The $100,000,000 natural industry seemed doomed. But the secret of the production of the synthetic material was found in several patents held by the Foundation, which American manufacturers promptly used to supply our market.

Ralph Waldo Emerson said: "An institution is the lengthened shadow of one man." This can truthfully be said of the Chemical Foundation. Francis P. Garvan was the mainspring of all of its activities during his lifetime. He was courageous, vigorous, and an encouraging leader. Educated a lawyer, he followed the legal profession—mostly in public service—until he became president of the Foundation. He regarded this work a patriotic service by which he could assist in developing in this country an industry it urgently needed. He devoted the last 18 years of his life constantly to this work. Through his wisdom and financial encouragement, Garvan made possible the American Institute of Physics as a cooperative agency for the publication, promotion, and the general advancement of physics in America.

While doing his utmost to assist in the development of an independent American chemical industry, Garvan always was watchful of any foreign encroachment upon our domestic industry. Such threats appeared and each time he was courageously outspoken in his denunciation of these attempts. In 1929 the assistant attorney-general of New York was urged to investigate the issuance of $30,000,000 in bonds of the American I.G. Chemical Corp. In 1931 a protest was sent to the Senate Finance Committee, regarding the granting of loans by American bankers to foreign competing chemical corporations. In 1932 Garvan spoke out against the foreign nitrate trust, and in 1934, when reciprocal trade treaties were first considered, he pleaded with the Tariff Commission not to make any changes in tariff rates on chemicals.

Testimony given before the Senate Finance Committee, on Feb. 12, 1937, shows that Garvan served the chemical industry for 20 years without pay; that he never had a postage stamp of expense; that he paid his own office rent and traveling expenses; and that he and Mrs. Garvan gave over $1,000,000 out of their own pockets to the cause. As a matter of fact, his staunchest ally and supporter in all of his work was Mrs. Garvan.

He had the cooperation and advice of foremost scientists and scientific organizations. The American Chemical Society presented him with the Priestley medal; the American Institute of Chemists gave its medal to him and Mrs. Garvan; the Synthetic Organic Chemical Manufacturers' Association gave him a bronze plaque; and Villanova College awarded him the Mendel medal. After his death, Nov. 7, 1937, many praiseworthy eulogies, editorials, and resolutions were spoken, written, and adopted. He lived for others: he sought no glory for himself, he preferred to remain anonymous. The Foundation, conceived and nurtured by Francis P. Garvan,

continues in its endeavors for the advancement of chemical and allied science and industry in the United States without financial profit to itself.

CIBA COMPANY, INC., derives its name from the Society of Chemical Industry in Basel, Switzerland. Its birthplace was the silk dyehouse of Alexander Clavel, who in 1859 began the manufacture of coal-tar dyes for his own needs. In 1873 the dyestuff business was sold to Bindschedler & Busch which 14 years later converted it into a limited company, the Society of Chemical Industry in Basel, now universally known as Ciba.

In the ensuing years, Ciba took a prominent part in the growth and development of the coal-tar dye industry. The first products were basic and acid dyes to replace alizarin. Then came azo acid, chrome, and naphtho-chrome colors which largely replaced natural coloring extracts. A constantly expanding research and development program led to azo derivatives substantive on cotton, diazotized and developed colors, and acridine derivatives such as brilliant phosphines. Ciba's new method for production of indophenol laid the foundation for the sulfur color series. This was followed by indigoid colors, which gave a comprehensive range of vat colors covering the whole spectrum. Shortly thereafter, Ciba developed anthraquinone vat colors, producing numerous patented specialties.

Diversified investigations produced several unique dye types: the Neolans, metallized wool colors where chromium is introduced into the dye molecule; the Chlorantines, metal-bearing direct colors with copper in the substantive molecule. The Coprantine line is a very recent development of substantive colors which are thereafter treated with an organic copper salt in the same dye bath, giving shades of increased light and wash fastness on vegetable fibers.

Extensive commercial growth was concurrent with this technical expansion. Through acquisition of, interest in, or affiliation with producing and distributing organizations in the principal countries, Ciba has become international in scope. Until shortly after World War I, Ciba products were distributed in the U.S.A. by various importers. When it became apparent that closer affiliations between the producing and selling organizations were necessary, Ciba decided to have its own company in this country. Feb. 1, 1921, it took over Aniline Dyes & Chemicals, Inc., controlled by Alfred F. Lichtenstein, and commenced operations under its new name of Ciba Co., Inc. Lichtenstein became president of Ciba Co. and continued in this capacity for 25 years. Under his able leadership the Company expanded and established branches in all of the principal textile centers. On the 25th anniversary of Ciba Co., Lichtenstein became chairman of the board and Dr. Harry B. Marshall became president, in which capacity he is continuing to broaden the activities of the Company. At about the same time that Ciba Co. was organized, the parent company extended its productive capacity in the U.S.A. through the establishment of the Cincinnati Chemical Works and by manufacturing agreements with the Dow Chemical Co.

In the distribution of dyes and textile auxiliaries, so many technical problems arise, that this cannot be properly classified as simply a selling proposition. Rather it becomes a research and development undertaking. So while Ciba Co. is essentially a selling organization, it also plays a very unique role in coordinating the technical developments in dyestuff manufacture with their practical application in dyestuff-consuming industries. By maintaining laboratories and technical staffs in numerous branches it keeps in close contact with the problems and requirements of the textile, paper, leather, and other industries using dyes, and so has been able to make valuable contributions to the techniques of bleaching, dyeing, printing, and finishing.

The parent company has producing units in Switzerland, France, Italy, Poland, England, and the U.S.A. Each unit has an extensive technical staff, and in Basel very comprehensive research laboratories are maintained. These various groups engage in fundamental studies of new or improved methods, products, higher yields, lower costs, etc., as well as consumer requirements and problems. With the diversified and extensive consumer field in the U.S.A., Ciba Co. has been able to serve the chemical industry by presenting its desires and needs for the consideration of these various groups.

Since its establishment in 1921, Ciba Co. has kept pace with rapid production and consumption of dyes in this country. It has aided in the expansion of vat color dyeing and printing, and developed the process for printing acid and direct colors on rayon for dress goods, and for printing fast-to-light direct colors on cotton and rayon for draperies. The Company has also been active in developed color dyeing, wool dyeing and printing, and such specialized branches as dyeing or printing acetate, nylon, spun glass, and other fibers or blends. It has also contributed largely to the rapidly growing process of coloring anodized aluminum.

Besides cooperating in the research programs of the various producing units, Ciba Co. also conducts research programs in its main and branch laboratories primarily on consumer problems covering fastness properties, application methods, and special requirements. The pure science research is conducted in the laboratories of the producing units.

The Company has been active in the development, production, and distribution of such auxiliary products as detergents, wetting agents, dyeing assistants, finishing materials, etc. During the war it cooperated with the various branches of the Armed Forces on specifications, tests, and materials and processes to meet special requirements. It also gave technical assistance to prime contractors furnishing materials to these various agencies.

CINCINNATI CHEMICAL WORKS, INC., a Delaware corporation, was organized in June 1920. On July 1, it purchased the Norwood and St. Bernard plants of Ault & Wiborg Co. at Cincinnati, in which certain dyestuffs and dry colors had been manufactured.

George F. Händel was elected president of the Company in July 1920, and has remained president to the present time. The general manager for the first 10 years was Dr. E. E. Misslin. He was succeeded by his assistant, Dr. Oskar Frey, who still occupies the position of general manager, with E. R. Brunskill as assistant manager and F. W. Theiler as chief engineer.

The Company is engaged in the manufacture of dyestuffs and pharmaceuticals. Since its inception, operations have grown steadily, as evidenced by its increased output and plant expansion. During World War II, Cincinnati Chemical developed the manufacture of DDT and was the first company in the United States to make this product.

COLGATE-PALMOLIVE-PEET COMPANY is the result of two important mergers which brought into one organization three old, successful soap companies. The oldest, Colgate & Co., founded in 1806 by William Colgate for the manufacture of soap and candles, was originally located in New York. Operating as William Colgate, then as Smith & Colgate, and from 1813 on as William Colgate & Co., the business was at first both wholesale and retail and the principal products were toilet soap and starch. Its first advertisement, of which there is any record, appeared in 1817. By 1847 the firm had outgrown its New York plant and the factory was moved to Jersey City.

With the death of William Colgate in 1857, the firm name was changed to Colgate & Co. The manufacture of starch was discontinued during 1866, about which time the Company started the manufacture of perfumes. By 1872 Cashmere Bouquet Soap was one of the Company's products and in the following year an aromatic tooth paste was introduced. In 1880 a glycerin department was added to the factory. Dental cream was introduced in 1896. Although chemists had been employed previously, a research laboratory was established in 1896 when Dr. Martin H. Ittner came with the Company. In 1906 the 100th anniversary of the Company was celebrated and at that time its products included laundry soaps, 160 different toilet soaps, and 625 varieties of perfumes. Up to this time the Company had been a partnership, but in 1908 a corporation was formed with, as was the case since 1813, all the officers members of the Colgate family. That same year the first Colgate clock was installed on the roof of one of the Jersey City factory buildings. In 1910 the entire Colgate organization was moved to Jersey City from New York. Sag Paste, a product used to protect the body from exposure to poison gas, and an antidimming material used on lenses in gas masks, were developed and manufactured during 1917-18. To obtain wider and more economical distribution, Colgate & Co. purchased the Indiana Reformatory at Jeffersonville, Ind., remodeling it in 1923 as a soap factory.

The B. J. Johnson Soap Co., later to become the Palmolive Co., was founded in 1864 in Milwaukee by Burdette J. Johnson and a Mr. Thing who subsequently sold his share to Johnson. In addition to manufacturing laundry soaps, this company also acted as agents for candles and cheese, and manufactured a cheese dressing used by dairymen in aging cheese. Palmolive Soap, at first a floating soap, was prepared in 1898 with olive and palm oils as a base. The purchase of a mill and plodder introduced at the 1905 World's Fair in St. Louis by a soap-manufacturing equipment maker from France, resulted in a new type of Palmolive Soap, and an intensive advertising campaign in 1911 so increased the sales that in 1916 the company name was changed to the Palmolive Co. The Crystal Soap Co., founded in 1872 in Milwaukee, was absorbed in 1919, and in 1923 both offices moved to Chicago. The same year a factory for the manufacture of Palmolive Soap was constructed in Sydney, Australia, and the following year the first Palmolive products were manufactured in Europe, at Paris.

In 1926 the Palmolive Co. merged with Peet Bros., which had been founded in 1872 by William, Robert, and Jesse Peet, who invested their combined capital of $800 in a one-story factory at Kansas City. By 1914 Peet Bros., specializing in laundry soaps, had a factory in West Berkeley, Calif. Merger of the Colgate Co. with the Palmolive-Peet Co. was effected in 1928, and the publicly owned corporation, Colgate-Palmolive-Peet Co., became one of the world's largest manufacturers of soaps, perfumes, and toilet articles. Charles S. Pearce, president of the Palmolive Co., became the first president of the combined companies.

In the meantime, manufacture of Palmolive Soap had been started in Hamburg and in Copenhagen. Merger of Crusellas y Cia., first established in Cuba in 1863, was concluded on Mar. 1, 1929, and in Oct. 1930 the soap manufacturers, Kirkman & Son, Inc., originally started in New York in 1837 by John Kirkman and moved in 1894 to Brooklyn, was welcomed into the affiliated interests of Colgate-Palmolive-Peet. S. Bayard Colgate, the fourth generation of his family in the soap business, became president of the Company in 1933, and Pearce was made chairman of the board. In 1938 E. H. Little became the third president of the Colgate-Palmolive-Peet Co.

The synthetic detergent Vel was introduced in 1937; a shampoo, Halo, the next year. In 1945 Veto, a deodorant cream, was marketed.

At the present time there are plants in Jersey City, Jeffersonville, Kansas City, Brooklyn, and Berkeley. Control laboratories are maintained in all plants to check the raw materials and the quality of the manufactured products, and the Research and Development Department is located at the Jersey City plant. Under normal conditions manufacturing is carried on in 2' foreign countries and Company products are sold in 72 countries and their colonial possessions. Among the best known of the products now on the market are Palmolive Soap, Super Suds, Klek, Colgate Ribbon Dental Cream, Colgate Tooth Powder, Cue, Palmolive Shave Cream, Colgate Rapid Shave Cream, Colgate Shave Stick, Colgate Barber Shave Soap, Palmolive Brushless, Colgate Brushless, Cashmere Bouquet Soap, Cashmere Bouquet beauty preparations (talcum, face powder, cold cream, lipstick, etc.), Halo, Palmolive Shampoo, Vel, Veto, Crystal White Laundry Soap, the Octagon line of soap products, and glycerin. In addition, industrial products are sold to wholesale consumers including laundries, schools, hotels, and industrial plants.

COLUMBIA CHEMICAL DIVISION, Pittsburgh Plate Glass Co., was established in 1899 as Columbia Chemical Co., one of the country's leading producers of alkalies, by John Pitcairn, a founder of the Pittsburgh Plate Glass Co. Incorporated on July 11, the Company's first board of directors was: W. L. Clause, Charles W. Brown, W. D. Hartupee, Artemas Pitcairn, and H. G. Chisnell.

John Pitcairn selected Hugh A. Galt, a 31-year-old Scottish chemical engineer with 10 years' experience in the American alkali industry, to locate a site, construct the plant, and supervise operations. Galt decided upon Barberton, O., near Akron, because of its geographic location, underlying salt strata, proximity to adequate transportation facilities, and the interest of civic leaders in having the new industry located there. Operations were started in 1900 with soda ash as the principal product. The Barberton plant became the fourth soda ash producer in the young American alkali industry. It was expanded rapidly during the next two decades and in 1920 became the Columbia Chemical Division of the Pittsburgh Plate Glass Co. During the same year, Galt was made a director of Pittsburgh Plate and vice-president in charge of the Division, positions held until 1940, when he retired from active service. He died on Feb. 24, 1947. Galt's successor, first as assistant superintendent of the Barberton plant and since 1940 vice-president in charge of the Columbia Chemical Division, has been Edwin T. Asplundh.

At the Barberton plant, soda ash is made by the ammonia-soda process from sodium chloride, limestone, ammonia, and fuel. Salt is obtained at Barberton from a deposit 60-100 ft. thick, about 2,800 ft. below the surface. Water is pumped down into the deposit and the saturated brine forced up is used as such in the process. Approximately 2,000 tons of limestone are burned with coke in lime kilns daily, and practically one-half of this tonnage consists of carbonic acid gas which is used to carbonate the salt brine after it has been impregnated with ammonia.

About 1919, Columbia opened up a limestone deposit at Fultonham, O., to insure a source of supply for the Barberton plant. Here large quantities of small-sized limestone and screenings eventually piled up to such an extent that they created a management problem. A Portland cement plant to use these limestone screenings was erected in 1923 and is now operating as the Columbia Cement Division of the Pittsburgh Plate Glass Co.

Two years after the Barberton plant was built, a caustic soda plant was added to the soda ash operation. Production of both alkalies has been greatly increased since that time. An electrolytic chlorine-caustic plant was added in 1936. Also produced at the Ohio plant are calcium chloride, chlorine, sodium bicarbonate, calcium

hypochlorite, Calcene (calcium carbonate), and Silene (calcium silicate). The last two items are used largely as rubber pigments.

An innovation in the shipment of caustic soda in tankcars was developed by the Columbia Chemical Division. Similar in appearance to the railroad tankcar, Columbia's specially constructed tankcars are highly insulated and fabricated by welding rather than riveting of seams. This process has eliminated leakage and metallic contamination. Although steam coils are supplied for instances of delayed emptying, they need not normally be used. With the advent of the tankcar and a special patented caustic-resistant lining developed by Columbia, liquid caustic, even at 73% concentration, can now be delivered at temperatures suitable for unloading into storage tanks, without the time necessary for steaming, and pure enough for the most exacting requirements.

When production started in 1900, Columbia appointed Isaac Winkler & Bro. Co. of Cincinnati, sales agents. Winkler handled sales until the spring of 1931, when the Columbia Alkali Corp. was formed as a wholly owned sales subsidiary. Late in 1940 the Chemical Division took over directly the sale of its own products with sales headquarters at its main offices, Fifth Ave. at Bellefield, in Pittsburgh.

The current board of directors for the Pittsburgh Plate Glass Co. includes: E. T. Asplundh, vice-president in charge of the Columbia Chemical Division, C. M. Brown, H. B. Brown, E. D. Griffin, Leland Hazard, J. H. Heroy, R. K. Mellon, H. F. Pitcairn, Raymond Pitcairn, R. B. Tucker, and H. B. Higgins, president.

When critical alkali shortages threatened to slow down the country's war program, Columbia constructed a large government chlorine and caustic soda-producing plant on the Ohio River at Natrium, W. Va. The Natrium plant, one of the largest chlorine-producing plants ever built as a single unit east of the Mississippi River, went into production in July 1943. It was purchased in 1946 by the Division from the Reconstruction Finance Corp.

Salt brine at the Natrium plant is pumped from wells more than 6,000 ft. deep, the deepest in the country. Another unique feature is that both liquid chlorine and caustic soda are piped directly into river tank barges. Production of the basic alkalies is still at capacity to supply the urgent needs of such heavy consumers as rayon, plastic, soap, chemical, synthetic rubber, and commercial dye manufacturers.

In Dec. 1944 Columbia acquired the assets of the Pacific Alkali Co. plant at Bartlett, Calif. Located in the Owens Valley, about 200 miles north of Los Angeles, the Bartlett plant currently is producing soda ash and sodium sesquicarbonate from various natural materials. It is mainly a mining and refining operation, but only a small fraction of Columbia's Barberton operation. Alkali brine is available from the bed of Owens Lake—a lake that went essentially dry in 1925 when the City of Los Angeles built a dam on the Owens River and by-passed the lake by means of an aqueduct. The bed of crystalline salts covers 16 square miles and at some places runs to a depth of eight feet.

In 1931 Columbia Chemical Division negotiated with the American Cyanamid Co. on erecting an alkali plant on the Gulf Coast. As a result, the Southern Alkali Corp., owned jointly by Pittsburgh Plate Glass and American Cyanamid, was formed and Corpus Christi, Tex., selected for a site because of its deep-water docking facilities and availability of natural gas for fuel. Construction of the Corpus Christi plant, using the ammonia-soda process, started in 1933.

Limestone was found in abundant supply on the Balcones Fault in South Central Texas, about 160 miles from the plant. A considerable part of the limestone, however, has been replaced by oyster shells recovered from a near-by bay. For its brine supply, Southern Alkali has developed the Palangana salt dome, about 60 miles from the plantsite. Fresh water from adjacent deep water wells is pumped into a

cavity in the solid dome of salt and the saturated brine formed continuously withdrawn from the bottom of the cavity. This brine is transported to Corpus Christi through a 60-mile cast-iron pipe line, entirely by gravity. When completed in 1934, this was believed to be the longest cast-iron pipe line in the world. Caustic soda and liquid chlorine are also produced at the Texas plant.

Early in 1946 Southern Alkali leased a major portion of a government-owned plant at Lake Charles, La., which had been built by another company during the war for the production of magnesium metal. The Lake Charles plant will be used to produce caustic soda and liquid chlorine. President and director of Southern Alkali since 1940 is Harold F. Pitcairn. Other directors are: William B. Bell, Clarence M. Brown, Kenneth F. Cooper, F. M. Fargo, Jr., James H. Heroy, Raymond Pitcairn, Frederick Pope, Eli Winkle , E. T. Asplundh, and Harold P. Eastman.

COMMERCIAL SOLVENTS CORPORATION was born of intensive World War I research in explosives and earned distinction as the pioneer producer of acetone and butanol by fermentation processes. Though synthetic methods are now also employed, the Company continues to be one of the foremost exponents of production by biological methods. In the past decade it has pursued a policy of diversifying its products and broadening its markets by expanding into fields other than solvents and industrial alcohol. While much of the output is still marketed to industrial users, anti-freezes, penicillin, and other newer products reach the public under the firm's own label.

With the outbreak of war in 1914, a desperate shortage of acetone developed in Great Britain. The chemical was required as a solvent in gelatinizing nitroglycerin and guncotton to make cordite, then used by the British Navy as a propellant for both cartridges and shells. Cordite made with defective acetone was blamed for the destruction of a British fleet off South America. In addition, acetone was required as a solvent for nitrocellulose dopes used in finishing airplanes.

As acetone was then obtained almost entirely from the distillation of wood that had to be dried six months, a frantic search was launched for a quicker process. This led to the University of Manchester where Dr. Chaim Weizmann, a Russian-born chemistry professor, was making butyl alcohol for an attempted synthesis of rubber. A bacterium had been found that fermented potato starch into butyl alcohol and produced acetone as a by-product. Later Dr. Weizmann developed a more efficient grain-feeding, spindle-shaped bacterium which was named *Clostridium acetobutylicum Weizmann.*

Cultures of this microorganism produced the required acetone at an unprecedented rate. The British Government adopted the process and started production at plants in England, Canada, and India. Dr. Weizmann refused personal honors from the British Government but asked official aid for the Zionist cause in which he was keenly interested. As a consequence, according to Prime Minister Lloyd George's *War Memoirs*, the historic Balfour Declaration was issued in 1917. "His Majesty's Government view with favor," said this fateful document, "the establishment in Palestine of a national home for the Jewish people, and will use their best endeavors to facilitate the achievement of this object." Dr. Weizmann devoted to the Zionist movement, of which he has long been a leader, the large peacetime royalties he later received under British and American patents.

After the United States entered the war, the U. S. Air Service and the British War Mission purchased the Commercial and Majestic whisky distilleries on the Wabash River at Terre Haute, Ind., and adapted them for acetone production by the Weizmann process. To manage the enterprise, the Joint War Board formed

the Commercial Solvents Corp. of New York. Between May 1918 and Armstice, 1,500,000 gal. of acetone were produced along with twice this amount of butyl alcohol for which there was then no demand.

Two members of the British War Mission, William A. Burton and A. H. Wykeham-George, interested a group of Americans in the commercial possibilities of the Weizmann process. These included David M. Goodrich and Henry Lockhart Jr., partners in a New York investment company, William D. Ticknor of the old Boston publishing family, and William S. Gray, Sr., president of a chemical sales firm. Goodrich was the son of the founder of B. F. Goodrich Co. and later became chairman of its board. Lockhart, who had been head of the materials section of the War Department, knew of the uses of acetone for aircraft dopes.

With the advantages in mind of cheap and readily available raw materials, this group purchased the Terre Haute facilities from the Government and acquired exclusive rights under the Weizmann patents for peacetime development of the war-born industry. Late in 1919 a new company, Commercial Solvents Corp. of Maryland, was incorporated. Its officers were: William D. Ticknor, president; William A. Burton, vice-president; and Philip G. Mumford, treasurer. Within a few months Burton returned to England to look after the foreign interests of the new company, Ticknor became chairman of the board, and Mumford, president.

As production was resumed in 1920, a series of events shifted interest from acetone to the hitherto useless butyl alcohol which had been stored in a huge tank. General Motors was seeking a faster method of finishing automobiles than by application of slow-drying varnishes. Edward M. Flaherty, a chemist of du Pont, discovered that a tough, quick-drying lacquer could be made by dissolving a low-viscosity, nonexplosive nitrocellulose in suitable solvents along with gums and plasticizers. The principal solvent, however, was amyl acetate, which was made from fusel oil, a by-product of whisky manufacture. With the advent of Prohibition, already limited fusel oil supplies shrank to practically nothing. Then it was found that butyl acetate and butyl alcohol could not only be substituted for amyl acetate in lacquers, but that the butyls had definite advantages.

Commercial Solvents registered the name Butanol, which is now the accepted name for butyl alcohol. The content of the big butanol storage tank quickly found its way into the new, fast-drying lacquer which permitted automobiles to be finished, better than ever before, in assembly-line operations that required only minutes instead of days. In 1921 the Company's orders for butanol greatly exceeded production.

Sales of solvents passed 10,000,000 lb. in 1922, but mysterious troubles with the bacteria developed near the end of the year which almost completely stopped production, when every lacquer manufacturer was pleading for more butanol. The Company's newly established Research Department spent months working out effective sterilization methods, and later a procedure was developed for immunizing the bacteria against infection. Meanwhile, to decentralize production and thus decrease the effect of a possible repetition of the catastrophe, a new and larger plant was started at Peoria, Ill. It was rebuilt from one purchased from U. S. Food Products Corp., situated on the Illinois River and convenient to corn, coal, water, and transportation.

While making solvents, the butanol fermentation also produced hydrogen and carbon dioxide, but Commercial Solvents for years allowed these gases to escape into the air. In 1926, as the Company's first venture into high-pressure, high-temperature catalytic synthesis, a plant was built at Peoria to turn these gases into ammonia. After a few months, it was decided that it would be more profitable to produce synthetic methanol. The switchover was effected simply by changing the

porous catalyst through which the gases were forced at high temperature and pressure. Commercial Solvents in the summer of 1927 became the first American company to market synthetic methanol. To supplement the supply of gases from the fermentation, natural-gas lines were later connected. Excess carbon dioxide from the fermenters, not needed to make methanol, was converted to dry ice.

Stimulated by the competition of synthetic butanol from petroleum, Commercial Solvents researchers in the early thirties developed a new strain of bacteria, named *Clostridium saccharoaceto butylicum*, which fed on molasses that cost less than corn and was cheaper to process. Shortages of molasses during World War II forced a return to corn.

Some ethyl alcohol had always been made as a by-product of the Weizmann process and, with the repeal of Prohibition, the Company expanded in this direction. Barrel storage warehouses at Terre Haute, sold after World War I, were repurchased and distillation of bourbon and rye whiskies and neutral spirits for the blending of whisky was started for bulk sale to bottlers and rectifiers.

In 1933 an important anti-freeze and industrial alcohol business, together with additional alcohol-producing facilities, were acquired with purchase of Rossville Commercial Alcohol Corp., and its subsidiary, American Solvents & Chemical Corp. of California. The purchase gave Commercial Solvents distilleries at Harvey and Westwego, La., and at Agnew, Calif., with a capacity for making 45,000,000 gal. ethyl alcohol a year from molasses. In 1937 the industrial alcohol business, but not the plants, of the American Commercial Alcohol Corp. was purchased.

At this time Commercial Solvents' line of anti-freezes was broadened to include Nor'way, an odor-free product compounded from its own methanol. In 1941 a permanent-type glycol anti-freeze was added under the trade name Peak. A complete line of cooling-system chemicals, cleaner, quickflush, stop-leak, and anti-rust, sold under the Nor'way brand, were produced to round out the line. In 1946 a large, new packaging plant was completed at Terre Haute for these products.

Since molasses was an important raw material, Commercial Solvents and Corn Products Refining Co. in 1935 formed the Commercial Molasses Corp. to buy the ships and terminals of the Molasses Products Corp. and the Dunbar Molasses Corp. With these purchases were acquired ocean-going molasses tankships, hundreds of tankcars, and loading and docking facilities in Cuba, Puerto Rico, and the United States. One of the Company's tankers was sunk by a German submarine during World War II. Commercial Solvents had been associated with Corn Products in two other enterprises. In 1930 both firms formed the Resinox Corp. for the manufacture of phenol-formaldehyde resins and resin varnishes. This was sold to Monsanto in 1939. Another venture with Corn Products was the British plant of Commercial Solvents, Ltd., built in 1935 at Bromborough, near Liverpool. This plant manufactured butanol, acetone, and ethyl alcohol. In 1938 it was sold to the United Molasses Co. which shortly thereafter resold it to Distillers Corp., Ltd.

In 1929 Commercial Solvents acquired the Commercial Pigments Corp., which had been organized to make titanium dioxide from ilmenite ore obtained in Travancore, India. In 1931 it was merged with two du Pont enterprises to form the Krebs Pigment & Color Corp. Commercial Solvents sold its stock in the latter to du Pont in 1934.

The important new field of vitamin production was entered by Commercial Solvents as an unexpected consequence of its expansion in the alcohol and whisky field. With the Terre Haute facilities devoted largely to whisky and spirits after the repeal of Prohibition, butanol production from molasses was concentrated at Peoria and 1,000,000 gal. of liquid fermentation wastes a day were run into the

Illinois River. The Illinois Conservation Commission demanded that the Company cease polluting the river.

This waste was a grave problem until Carl S. Miner, a consulting chemist who had aided the Company on more than one occasion, suggested the dried waste be analyzed for vitamins. The residue was found to be rich in riboflavin (vitamin B_2 or G). Moreover, the fermented corn residues also contained riboflavin in only slightly lower concentration. A process for salvaging the vitamin was worked out and promptly patented. In 1938 Commercial Solvents began producing riboflavin supplements for poultry and livestock feeds, under the trade names of B.Y. and B.Y.-21. Subsequently a new, large-scale process for producing crystalline riboflavin by deep-vat fermentation was installed at Terre Haute. Production was such that the price was reduced from $12 per gram in 1939 to 15¢ per gram in 1945. In 1946 Terre Haute's riboflavin plant and Peoria's vitamin-feed recovery facilities were further expanded.

In the middle thirties, high-pressure synthesis activities of Commercial Solvents were expanded by development of the nitroparaffin process utilizing natural gas. Dr. Henry B. Hass, head of the Chemistry Department at Purdue University, undertook to combine the hydrocarbons of natural gas with nitric acid to make a new family of aliphatic nitrohydrocarbons and their derivatives. Commercial Solvents quickly obtained rights to his patents from the Purdue Research Foundation, employed Dr. Hass as an advisor, and added several of his graduate students to the research staff. From the four basic nitroparaffins obtained by the nitration of propane (nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane), more than 1,000 products were made in the laboratory. In 1940 an oversized pilot plant went into operation at Peoria to make 16 of these products, which quickly found uses in nearly every branch of the chemical and allied industries. Expansion of the nitroparaffin development was retarded during World War II, but was resumed in 1946.

Another interest of Commerical Solvents involving natural gas has been the Thermatomic Carbon Co., Sterlington, La., which cracks gas in special furnaces to make fine grades of carbon black. Management of Thermatomic on a contract basis was assumed in 1931 and a majority interest in it acquired in 1938. In 1944 this subsidiary enlarged its carbon plant to meet the requirements of the war synthetic rubber program.

Because of the Company's success with gas operations, Army Ordnance in World War II asked it to construct and operate a plant for anhydrous ammonia. The new plant was located adjacent to the Thermatomic operation because of the availability of natural gas and rail facilities. Known as the Dixie Ordnance Works, it has a rated capacity of 150 tons per day. After the war, the Company purchased the Works from the Government and rechristened it the Dixie Chemical Division. The plant was reconditioned and operating at rated capacity by the end of 1946. One of the incompleted units was redesigned for synthetic methanol production.

Penicillin was another novel but logical World War II expansion. The pharmaceutical field was entirely new to the Company, but its 25 years' experience in large-scale fermentations made the step a natural one. After the Department of Agriculture's research laboratory in Peoria had discovered that corn steep-liquor would yield many times the amount of penicillin produced by other media, Commercial Solvents became interested and in 1943 built in record time a large penicillin plant at Terre Haute.

A special mold was found to produce penicillin as prolifically when submerged in an agitated steep-liquor mixture as when on a quiet surface. Together the two

discoveries meant that penicillin might be produced in large tanks much as butanol and acetone. Up to that time all penicillin had been produced in necessarily small quantities from surface culture in bottles. A deep fermentation plant was designed with a rated monthly capacity of 40 billion Oxford units of the drug. Beginning in Aug. 1943, laboratory work, pilot-plant development, and full-scale construction were carried on simultaneously. The plant got under may the last of Jan. 1944—in less than nine months was accomplished what normally would have required two or three years.

Since that time Commercial Solvents' penicillin production has increased enormously, reaching over 500 billion units in 1946. The Company was the first to produce commercially pure crystalline salts of penicillin. With mounting production rates came reductions in prices. Although the drug was sold by surface-culture producers in 1943 for $20 per 100,000 units, the Company was able to quote $3.20 per 100,000 units even in 1944. In Dec. 1946 the price was down to 42¢.

In 1946 Commercial Solvents began erecting a plant for commercial manufacture of a new and potent insecticide—benzene hexachloride—another product with little chemical relationship to products previously made. Another 1946 expansion was the acquisition of the Pennsylvania Alcohol & Chemical Co. and its 47-acre plant at Carlstadt, N. J., which produces alcohols, solvents, clear-base nitrocellulose solutions, and pharmaceuticals.

Besides the Carlstadt property, Commercial Solvents owns and operates plants located in Terre Haute, Ind., (3); Peoria, Ill.; Sterlington (2), Harvey, and Westwego, La.; and Agnew, Calif. Its management is headed by Maj. Theodore Penfield Walker, chairman of the board. Other officers are: Henry E. Perry, vice-president; Henry W. Denny, vice-president, sales; Kenneth H. Hoover, vice-president, research; Maynard C. Wheeler, vice-president, production; Howard L. Sanders, treasurer; Anthony H. Braun, controller; and A. R. Bergen, secretary. General offices are at 17 East 42nd St., N. Y. City.

In addition to its own research staff headed by vice-president Hoover, Thomas S. Carswell, manager, and Dr. Jerome Martin, director, Commercial Solvents has a Research Advisory Council composed of outside consultants, with Carl S. Miner as chairman. The Company's bacteriological and chemical research and development activities are centered in a modern glass-brick research laboratory completed at Terre Haute in 1941 to replace a structure destroyed by fire.

CORNING GLASS WORKS developed from a small glass factory started by Amory Houghton, Sr., in Somerville, Mass,, in 1851. Houghton named his new company, in which his sons Amory, Jr., and Charles F., were associated, the Union Glass Co. In 1864 Houghton, Sr., sold Union Glass and acquired a going glass concern in Brooklyn, N. Y., which he reorganized as the Brooklyn Flint Glass Co. The Brooklyn business was conducted with varying success until 1868 when, influenced by favorable offers from leading businessmen in Corning, N. Y., the Houghtons decided to close up and establish a new company at Corning, to be known as the Corning Flint Glass Co. This move was made in the expectation of more favorable labor conditions, and because Corning was near the soft coal fields of northern Pennsylvania, it had abundant cheap wood for fuel and good shipping facilities by rail and canal.

In 1875 the Corning Flint Glass Co. was reorganized and incorporated in New York as the Corning Glass Works. Meanwhile, Amory Houghton, Sr., had retired and Amory Houghton, Jr., became president and treasurer, with Charles F. Houghton, vice-president. The Houghton brothers had foresight and marked ability, and under their management the Company became firmly established and increased in

strength and importance in the glass industry. Flint glass for tableware and other decorative articles, railway signal lenses, lantern globes, thermometer and other types of tubing, pharmaceutical and similar wares were manufactured.

Between 1875 and 1900 the Company grew and its sales increased. The outstanding addition to its line was bulbs for incandescent lamps. In 1879 Charles F. Houghton learned that Thomas A. Edison, then in the midst of his incandescent lamp development, needed a glass envelope which would seal with platinum. He was using short wires of platinum leading through the glass to connect with the illuminating filaments within. Corning for years had specialized in lead glasses and on the chance that one of them would have an expansion coefficient near enough to that of platinum to make the seal possible, Houghton visited Edison and persuaded him to accept samples of Corning glass for trial, which proved satisfactory. The first bulbs were all free-blown, that is, blown without a mold to limit size and shape. With the rapid electrification of lighting systems, bulbs for incandescent lamps became in time one of Corning's important products.

In 1887, and while Amory Houghton, Jr., was president, his second son, Arthur Amory, joined the Company as assistant to his father. Two years later the oldest son, Alanson Bigelow followed, becoming sales assistant to his uncle, Charles F. Houghton, and on the latter's death, manager of sales. A Harvard graduate, he later served as Congressman and U. S. Ambassador to Germany and England.

In 1899 Alanson Houghton, then manager of sales, heard a paper on color blindness given by Prof. E. W. Scripture of Yale, before the Railroad Club of N. Y. City. He was so impressed by the fact that correct signal colors could be determined only by a careful study of color theory and color perception, together with the physical conditions involved, that he asked Prof. Scripture to undertake a laboratory investigation with the view of establishing correct color values for each of the colors possible for signal use. At that time one of the weak spots in railway engineering was a serious lack of uniformity in the colors used in signal practice. The color standards of no two railways were alike. For example, Corning Glass carried a dozen or more sizes and styles of lenses in each of the 32 shades of green then in use. Under foggy or stormy weather conditions many of the colors were subject to confusing changes.

Prof. Scripture started his investigation in 1901 in New Haven, and from 1903 on, Dr. William Churchill of his staff, continued the work in Corning. The object was to obtain colors combining the most distinctive hues with the highest possible transmission. All available glasses were subjected to spectrophotographic analysis, photometric tests, actual range tests under different weather conditions, etc., until the selection was narrowed down to one definite medium shade in each of the several colors. There were finally developed a red possessing high transmission without appearing orange; a slightly bluish green with nearly 50% increase in transmission; a yellow, midway between red and green, of somewhat diminished intensity. New glasses to correct the color faults of those in use required many months to produce and in the meanwhile a careful study was being made of lens design. The response of the railroads to the results of this investigation was immediate, and three years later the Railway Association adopted standard specifications embodying the new colors exactly as Corning Glass had worked them out.

During the 1890's, Corning Glass was approaching a change in policy toward the possibility of producing new types of glass. The younger Houghtons were visualizing new glasses of unusual hardness and great heat-resistance, which might find commercial uses. The glasses common in those days were for the most part of the standard lime and lead types. Since there was practically no experience among American glassmakers to guide them in making the newer types desired,

a bold step was decided upon: to employ competent scientists, give them a properly equipped laboratory, and get the fundamental chemical and physical facts about glass as a basis on which to build. The Houghtons were encouraged and greatly aided by Dr. Arthur L. Day, then in charge of the geophysical work of the U. S. Geological Survey, who was retained in an advisory capacity in 1905.

The Research Department was started in 1908, with Dr. Eugene C. Sullivan, formerly in the Chemical Division of the Geological Survey, as its director. Dr. Sullivan chose as his assistant in chemistry William C. Taylor, an M.I.T. graduate, and in 1913, as his chief physicist, Dr. Jesse T. Littleton, instructor at the University of Michigan. The Department's scope of the study has widened in many directions since 1908, but the largest part of the work has been directed to the long-haul objective. Thus far, the results achieved seem to justify the soundness of that policy. From time to time the Department has also cooperated in research with the colleges and with the Mellon Institute. It furnishes daily checks on melting and other processes to the Manufacturing Department and is responsible for each of the 400-odd glass compositions currently being melted in Corning's plants. During the years it has accumulated a great amount of information on the characteristics and behavior of glass, particularly its own new glasses, and has in reserve some 50,000 other formulas.

One of the Laboratory's early problems was a study of borosilicate glasses primarily to meet the demands of the railroads for stronger lantern globes and signal lights than were then in common use. This resulted in the development of a number of glasses which, by their low expansion, heat resistance, hardness, high chemical stability, and a number of unusual electrical properties, not only met the railroad's needs but opened new vistas for the use of glass. They made possible the new art of cooking in glass dishes; also the production of a line of laboratory glassware just when shipments of Jena glass were stopped by the First World War. From it developed many types of glass chemical apparatus and a line of insulators that substantially contributed to the success of present-day transcontinental communication.

More recently glass has been developed for construction of the disc, 200 inches in diameter, for the mirror of the California Institute of Technology's great telescope on Mt. Palomar. Another outstanding development now in operation is the production of ware containing 96% silica, which, when red hot, can be plunged into ice-cold water without breaking. In the optical glass field the Laboratory has devised glasses for filtering out or for transmitting specific bands of the spectrum all the way from the X-rays through the ultraviolet and visible into the infra-red. The manufacture of low-cost bulbs for incandescent lamps and radio tubes by continuous processes on automatic machines was materially assisted by the Laboratory's development of soda-magnesia-lime glasses and by Corning's demonstration that such glasses could be adapted successfully to tank melting and working. The most outstanding contribution to the problem of glass refractories was the development of a new type of tank block now sold under the trade-mark Corhart. These blocks, made by melting materials in an electric furnace and casting into molds, are used today in some 80% of the glass tanks operated in this country. Of interest also, is a new method of sealing different pieces of glass by the use of electric currents.

Since its founding, Corning Glass Works has had eight presidents, five of them members of one family line. In many ways this family control has been of importance, especially in developing and stabilizing the Company's policies. Perhaps the best index of its growth is shown in its employment figures: 1920, 3,450; 1940, 5,520; 1946, 11,634.

The brothers Alanson B. and Arthur A. Houghton started a new era in the Company's growth. Under their regime, a plant for bulbs was constructed at Wellsboro, Pa., in 1916. In 1918 a small glass plant in Corning was purchased for additional bulb production. In 1919 a vacant plant at Kingsport, Tenn., was bought and revamped for making heat-resistant glass ovenware.

During the presidency of Alexander D. Falck (1920-28), the Company began to develop connections with foreign glassmakers. In France, the Société Le Pyrex was organized in which Corning Glass Works had an interest, and in 1922 licenses were granted it to manufacture and sell Pyrex-brand products. That year similar licenses were granted to James A. Jobling & Co. of England. In the United States licenses to manufacture and sell heat-resistant glassware were given to H. C. Fry Glass Co. of Rochester, Pa., in 1920, and to McKee Glass Co. of Jeanette, Pa., in 1921.

The Kingsport plant was sold to the Blue Ridge Glass Corp. in 1925, Corning retaining approximately a one-third interest. This company was organized by two European glass manufacturers to produce rolled figured and wire glass. In 1924 a plant at Central Falls, R. I., was purchased for additional bulb-manufacturing capacity and Corning Fiber Box Co. was organized to insure prompt deliveries of packing material. The Corhart Refractories Co., with a plant at Louisville, was organized in 1927 to manufacture electrocast refractories for melting furnaces, previously developed by the Research Department.

Dr. Sullivan succeeded Falck as president in 1928 and served until early in 1930. Continuing as director of research, he ably sustained and increased the Company's growth along the lines of its established policies. The Fall Brook unit for the mechanical drawing of tubing was built in Corning in 1930.

During the presidency of Amory Houghton (1930-1941), the tempo of the Company's growth continued and increased. In 1933 Steuben Glass, Inc., was organized (fully owned) for the retail sale of Steuben decorative ware, with shops in N. Y. City, Chicago, and Palm Beach. The consolidation of Corning Glass with Macbeth-Evans Co. of Pittsburgh was consummated in 1936. Next year the Pittsburgh Corning Corp. was formed jointly by the Pittsburgh Plate Glass Co. and Corning on a 50:50 basis, to manufacture and sell hollow glass construction blocks and similar articles developed by the latter. In 1938 the Owens-Corning Fiberglas Corp. was similarly formed with Owens-Illinois Glass Co. to manufacture fiberglas products. The initial factory was at Newark, O., and additional plants have been built at Ashton, R. I., Huntington, Pa., and Kansas City, Kans.

Under president Glen W. Cole (1941-46) occurred the organization of the Dow Corning Corp. (1943) jointly with the Dow Chemical Co. for commercial production, primarily for war purposes, of organo-silicon compounds known as silicones, originally developed by Corning Glass chemists. In 1942 Corning designed and built an optical glass plant in Parkersburg, W. Va., for the Government. In 1944 it leased part of this plant for the manufacture of chemical and apparatus ware, and in 1946 purchased it outright and installed glass tube-drawing facilities.

During World War II more than 75% of the Company's production was for war use, including Army-Navy messware, radar, radio, and proximity fuse bulbs, optical glass for bombsights, navigating devices, periscopes, field glasses, range finders, and fire-control equipment, laboratory and medical glassware, and instrumental panel and navigation lights for aircraft and marine vessels. In addition, a wide variety of precision-finished and other special products were made. Corning worked on 174 research and development projects for the three branches of the service and was awarded 14 Army-Navy "E's."

In 1943 Corning took its first step in developing wider South American markets

by acquiring a minority interest in the leading glass-manufacturing company of Argentina, Cristalerias Rigolleau of Buenos Aires. The following year a similar interest was acquired in Cia. Vidraria Santa Marina of Sao Paulo, Brazil, in 1945 in Cristalerias de Chile of Santiago, Chile, and in 1947 in Christaleria Peldar of Medellin, Colombia. The first of these affiliations has already resulted in the successful production of Pyrex-brand baking and chemical ware, and other Corning products are being manufactured in Brazil and Chile. To meet the demands of the increasing Canadian trade, a glass plant at Leaside, near Toronto, was purchased and is being operated as Corning Glass Works of Canada, Ltd., a wholly owned subsidiary.

The officers and directors of Corning Glass Works, as of May 1, 1948, are Amory Houghton, chairman; G. W. Cole, vice-chairman; W. C. Decker, president; G. D. Macbeth, vice-president and controller; W. H. Curtiss, vice-president and secretary; C. D. LaFollette, vice-president and treasurer; A. D. Falck, honorary chairman; E. C. Sullivan, honorary vice-chairman; A. A. Houghton, George Murnane, Halsey Sayles, H. C. Shepard, and B. C. Wright. The additional officers include H. M. Hosier, J. T. Littleton, W. C. Taylor, and E. W. Ritter, vice-presidents; A. L. Day and G. B. Hollister, honorary vice-presidents.

CROSBY CHEMICALS, INC., grew out of the wish of the Goodyear Yellow Pine Co. to clear the stumps from its cut-over pine lands preparatory to planting tung oil trees. L. O. Crosby, Sr., president of Goodyear, had tried without success to interest some of the major wood naval stores producers in building a plant at Picayune to process the stumps. The Crosby family wanted a plant established in the vicinity to take care of the employees who had worked or were working for Goodyear. The producers were willing to take the stumps but would not build a plant, neither would they give any definite commitment as to how soon they would remove the stumps. Goodyear decided to erect its own plant.

Under R. H. Crosby plans were drawn for a 250-ton-per-day FF rosin plant, contracts were awarded, and construction started in the spring of 1937. A personnel organization of several experienced wood naval stores men was meanwhile being built up and placed in key positions. Erection of the plant was completed in November, operations starting on the 7th. By Dec. 10, when the first drum of FF rosin was produced, all the "kinks" of operation had been ironed out. Crosby Naval Stores, Inc., was incorporated in Mississippi in 1938, with R. H. Crosby, president, H. H. Crosby, vice-president, and L. O. Crosby, Jr., secretary.

During construction, R. H. Crosby tried unsuccessfully to obtain a license for a rosin-decolorizing process from established naval stores producers. The problem was assigned to the Research Department which after several failures discovered and patented the process now being used, in 1939. The process was first tried out in a pilot plant before a semicommercial plant was built. The gratifying demand for Crosby products necessitated a larger plant which was constructed and began operating Mar. 1940. The stump capacity was stepped up to 600 tons per day in September, making Crosby Chemicals one of the three largest producers of wood naval stores products in operation.

The demand for the Crosby "Mark of Quality" products continued to increase and a second plant was decided upon. Due to its location in the middle of thousands of acres of virgin stump land, on three railroads and within 50 miles of a deepwater port, De Ridder, La., was the site selected. Construction started in the summer of 1945; completed and in operation, Nov. 1946. The De Ridder plant was designed for 1,000 tons (stumps processed) daily capacity.

In 1946 the name Crosby Naval Stores, Inc., was changed to Crosby Chemicals,

Inc., better to describe the products produced and also to avoid the confusion the general public associates with naval stores, namely ships, boats, and marine equipment. Crosby Chemicals now produce approximately 100 varieties of rosin and terpene products, the more important being all grades of wood rosin, resins, paper size, turpentine, pinene, dipentene, terpene solvents, and several grades of pine oil and related products. It has grown into a large organization capable of processing 1,600 tons of stumps daily, employing 500-600 men in plant operation and 1,000-1,200 in stumping operation. Main offices are at De Ridder.

The present officers are L. O. Crosby, Sr., chairman of the board; R. H. Crosby, Sr., president; R. H. Crosby, Jr., vice-president and treasurer; Thomas L. and Richard C. Crosby, vice-presidents; and Margaret Crosby, secretary.

DAVISON CHEMICAL CORPORATION has roots reaching back over 100 years. Although its present name dates from the time of reorganization, Oct. 30, 1935, by Chester F. Hockley, its present president, the name "Davison" has been a living symbol of its original founder, William Davison. The business was started in 1826 by this Scotch-Irishman and an old photograph shows the sign, "Davison, Kettlewell & Co.: Grinders and Acidulators of Old Bones and Oyster Shells."

This is a far cry from the character of the present corporation with its modern contact acid plants, the largest superphosphate plant of its kind in the world under one roof, extensive phosphate rock mining operations in Florida, and research-developed silica gel catalyst plant at Curtis Bay, Md., and Cincinnati. But the great energy and foresight of William Davison still exists in the management's determination to carry on his tradition of building for the future. Purchase of the Florida properties of the Southern Phosphate Corp. near Bartow in 1946, and of a modern silica gel catalyst plant at Cincinnati in 1947, indicate this purpose.

Davison Chemical Co., the predecessor of the present Corporation, succeeded to a business founded in 1832 as a partnership. It was in this year that William Davison built the first sulfuric acid chamber in the United States. From old bones and oyster shells as a base, came the phosphoric acid of those days. The powdered bones were dumped into a large pit in the ground; while one man poured in sulfuric acid, others stirred the mass with large wooden paddles and the material when "set" was shoveled out and screened. This business went into different hands, Davison-Symington & Co., while William Davison interested himself in William Davison & Co., which concurrently with fertilizers, manufactured quinine, calomel, Epsom salt, and heavy drugs.

William Davison had seven sons and in 1902 one of these, Calvin T. Davison, formed Davison Chemical Co. of Baltimore County, incorporated under the laws of Maryland. In 1920 its name was shortened to Davison Chemical Co. Thus it remained until 1935, when the plan of reorganization as proposed by Chester F. Hockley, then receiver, was accepted by the court. At that time Davison Chemical Corp. acquired the assets and properties of the old Davison Chemical Co. This was but another step in the survival through the years of the name "Davison."

Until 1908 Davison operated two sulfuric acid plants, at Canton and Hawkins Point on the west side of the Patapsco River. At that time the present Curtis Bay works was built on property known as Chairs Farm at Sledds Point, the deep-water section of Baltimore harbor. The Company manufactured only sulfuric acid, but due to the seasonal demand for acid, it became difficult to operate at full capacity. Therefore, in 1914, the acid phosphate plant was begun, which gave greater flexibility to the business and greatly widened its field. Then the Company purchased several outside branch fertilizer plants.

During World War I the Company's research staff developed a material which in World War II gained universal fame as a dehydrating agent. This product, "silica gel," later became the basis for the fluid catalyst used in the production of high-octane gasoline.

Through research, development, and expansion, the Corporation today offers a wide variety of industrial chemicals and processes and is an important producer of industrial chemicals, superphosphates, and mixed fertilizers. It is one of the leading producers of sulfuric acid, a large percentage of which is distributed to non-fertilizer industries. Davison makes both chamber and contact acid, also hydrofluosilicic acid. Alum (aluminum sulfate) has been manufactured in a subsidiary plant located in Columbus since 1930.

The Research Department developed asphalt compounds which surpassed all tests of the joint Army-Navy research groups during World War II. These compounds are: (1) Protek-Coat, an asphalt coating compound for forming a protective moisture-vapor-proof and weatherproof barrier on cartons, crates, and other containers by cold spray application, deadens sound and protects metals against corrosions; (2) Protek-Seal, an asphalt mastic sealing compound for forming waterproof and moistureproof seams and closures on all types of creped and crinkled waterproof paper, also an excellent caulking compound; (3) Protek-Film, a quick-setting asphalt hot-dipcoating compound for moistureproofing packages and the sealing of cork insulation and containers; (4) Davison Crate Top Coating, an asphalt compound for waterproofing the tops of fully sheathed crates; (5) Fendix, automobile underbody protective coating and sound deadener.

Silica gel is a clear, granular, nonabrasive, and chemically inert silicon dioxide, having an unusual pore structure which gives it a surface area of about 50,000 sq. ft. per cu. in., capable of absorbing up to 45% of its weight of water from saturated air. The removal of condensable vapors, especially water vapor from air and gas mixtures by means of silica gel is finding wide application in industry today. Its major use is as desiccant or dehydrating agent for drying air in enclosed spaces and in containers used for shipping or storing materials, protecting the item packed against mold, mildew, rust, or corrosion. It is used to protect business machines, machined parts, instruments, automotive, electrical, or radio parts, airplane engines, hygroscopic chemicals, narcotic drugs, gelatin capsules, and even fabric-lined caskets. Protek-Sorb silica gel is used for dehydrated packaging and for drying cable splices in the telephone industry. Silica Gel Air Dryers (silica gel contained in perforated metal containers) are used to protect delicate instruments, scales, tools, papers, records, films, etc., against moisture damage; impalpable silica gel applications vary from the active ingredient in an absorptive medicated powder to a catalyst or catalyst carrier; refrigeration-grade silica gel was developed especially for the dehydration of refrigerants.

Potassium, ammonium, magnesium, zinc, and sodium silicofluorides are made by the Corporation, as well as granulated superphosphates (20% P_2O_5), nongranulated superphosphates (run of pile, guaranteed minimum 20% P_2O_5), ammoniated superphosphate (5% N, 16% P_2O_5) and complete mixed fertilizers. The Corporation has coordinated research and development with its Engineering Division, which offers industry consulting service in allied fields, as well as designs and supplies silica gel dehydrators for compressed gases, inert gas generators, and other special equipment.

Plants for the manufacture of industrial chemicals, fertilizers, and other products are located at Curtis Bay, Baltimore. Fertilizers are produced at Columbus (where alum is also produced) and Alliance, O., Savannah, Gretna, La., Nashville, Perry, Ia., and New Albany, Ind. The recently acquired mining properties near Bar-

tow, Fla., have become the Phosphate Rock Division. This acquisition places Davison in a very advantageous position in the fertilizer and chemical industry, as it will supply the Company's own phosphate requirements, in addition to being able to furnish tonnage of essential phosphate for industry and agriculture at home and abroad. The acquisition of the modern catalyst plant at Cincinnati has added to Davison's considerable catalyst production at the Curtis Bay works and to the flexibility of operation quite necessary in this particular chemical field.

Officers of the Corporation as of July 1, 1947, are: president, C. F. Hockley; executive vice-president, M. G. Geiger; vice-president, branch plants, K. D. Morrison; vice-president, engineering, E. B. Dunkak; vice-president, operations, G. M. Hebbard; vice-president, marketing, R. L. Hockley; vice-president, research, C. E. Waring; secretary-treasurer, M. C. Roop; comptroller, W. B. McCloskey; assistant secretary-treasurer, J. E. Hardesty; and assistant comptroller, F. J. Griffin.

DETROIT CHEMICAL WORKS, originally established in 1889 to produce acid phosphate of lime for baking powder manufacture, has passed through changing phases of fortune and misfortune and as to the nature of its products. Its early history is interwoven with that of its founder and long-time leader, John Davis, who was born in Westfield, Mass., in 1844, son of Rev. Emerson Davis, widely known educator and clergyman, and Mary Mayhew Folger, direct descendant of Peter Folger, grandfather of Benjamin Franklin. Davis left Westfield Academy at 15 to work in a drugstore and during the Civil War served as a hospital steward at the field headquarters of Generals Meade, Hooker, and Sheridan. Upon discharge from the Army in 1865, he returned to Westfield and the drug business but in 1868 migrated to Michigan and established his own drugstore in Wenona (West Bay City), where he became for a time a town council member. Soon he began concocting side lines such as tooth powder, hand lotions, perfumery, flavoring extracts, and baking powder, which he peddled himself in his own and neighboring communities.

In 1879 he moved to Detroit with his wife and three small sons. Here he organized a grocer's specialty business under the name John Davis & Co., a limited partnership with three wholesale grocers of Flint, which in 1888 was dissolved and succeeded by a corporation under the same name. This business continued until 1895 when a catastrophe, remembered as the "Journal Explosion," completely demolished the building it occupied, with the loss of many lives. Meanwhile, having acquired the know-how in a small pilot plant in space adjoining the specialty business, John Davis had in 1889 set up the Detroit Chemical Works as a separate unit to manufacture acid phosphate of lime. Located about three miles west of downtown Detroit, it first operated as part of John Davis & Co.

In 1893 the Detroit Chemical Works was incorporated, with John Davis and Robert B. Davis of New York (no relation) holding equal shares. For the paid-in capital of $12,000 they acquired the entire interest of John Davis & Co. in the plant. Robert B. Davis, owner of the Davis O. K. Baking Powder Co. of Hoboken, N. J., became the chief consumer of the Company product and so continued through 1903. In 1897 John Davis became sole owner of the Company. His second son, J. Folger, who had left school at an early age to join his father, continued with the Company as vice-president until 1910, when he entered the real estate and building business. The eldest son, Edward S., after several years as a newspaper reporter and as salesman for John Davis & Co., came to the Company in 1899 and was made secretary-treasurer. In 1909 the youngest son, Emerson, upon graduation from the University of Michigan, where he had specialized in chemistry, joined the Company as treasurer.

The business grew in a modest way from the start and land and buildings were added as needs arose. In 1897 calcined soda alum, another baking powder ingredient better known as C.T.S., cream of tartar substitute, had been brought into production and shortly thereafter, sulfate of alumina (papermaker's alum). The latter completely supplanted the other two products by 1904. While the phosphate had chiefly gone to the two Davis companies and the soda alum largely into the South and Midwest, the sulfate of alumina found an extensive outlet in the paper areas of Michigan, Wisconsin, Ohio, and New York.

At the turn of the century Detroit's chemical industry was in its infancy. Michigan Carbon Works (now of the American Agricultural Chemical Co.) was well established, making fertilizer and gelatin with its own supply of sulfuric and muriatic acids. Church & Dwight had tapped in a small way the salt deposits of the down-river section near Trenton for manufacture of saleratus. The pharmaceutical houses of Parke, Davis & Co. and Frederick Stearns & Co. had developed to major proportions. In 1895 the Solvay Process Co. had come into the area and was producing alkalies in a large way. Up to this time Solvay and Detroit Chemical were the only quantity consumers of sulfuric acid. By combining purchases they bought more favorably from the zinc plants of central Illinois. In 1901, however, upon expiration of contract, a sharp rise in price caused the Detroit Chemical Works to erect its own lead chamber acid plant. A preferred stock issue was authorized and sold, and later increased to $146,000 to provide for muriatic, nitric, and mixed acid manufacture and concentration of sulfuric acid. This preferred issue represents the only capital brought into the business beyond the original $12,000, and has long since been reduced to about $77,000.

The sulfuric acid plant went into production in early 1903 and has been in continuous operation ever since. Renewed in part from time to time, it is now (1947) emerging from a major operation of rejuvenation as a plant practically 80% new, with greatly improved efficiency and increased capacity. In the dozen years following the venture into the acid business there were many setbacks: two fires gutting separate departments; prolonged litigation defending injunction proceedings seeking to oust the chemical plant; lack of a home market compelling sale of surplus capacity at a distance against adverse competitive conditions; and lack of capital to meet these undue expenses all but proved the undoing of the Company. Only the loyal support of stockholders, the patience of creditors and the bank, later the kind offices of a competitor aiding in transferring its heavy indebtedness into a mortgage loan, carried the Company over this critical period. Finally, at the outset of World War I, the frantic buying by foreign governments of all surplus stocks and at ridiculous prices bid by themselves disposed of the overhanging debt and put the Company back on its feet.

In the early twenties the automobile industry began expanding, bringing in a broad line of accessory and metalworking industries, creating an ever-increasing and heretofore lacking home market for the various acids. This, together with the depressed price of alum then prevailing, led the company in the later twenties to concentrate upon acids alone.

John Davis remained president until his death in 1926 at the age of 82, though he had gradually surrendered the active management to his sons, Edward and Emerson. The board of directors consisted of two representatives of the preferred stock and the three Davises. One of these shareholders, Harry Bullock, though never active in the Company, was early named vice-president and has so remained till he is now 83, but still strong and alert. Following John Davis' death, preceded a year or two by that of William E. Reilly, the fifth director, no changes were made. In Oct. 1939, Edward Davis died after a prolonged illness and a general

reorganization was effected. Emerson Davis was made president and general manager; Bullock continued as vice-president; Herbert Schumann, son-in-law of Folger Davis and with the Company since 1936, became treasurer; and Nelson B. Green, with the Company since 1911, as accountant, office manager, traffic manager, and sales manager, was named secretary. These four constitute the board of directors with Paul H. Townsend, son-in-law of Edward S. Davis and vice-president and general manager of the Huron Portland Cement Co. In 1942 Philip C. Davis, son of Emerson, came to the Company after eight years of government service in administrative posts and the past two years has served as manager of plant operations. Mary Sutherland, who has been with the Company since 1918, and Ceile Brown, whose service dates from 1926, complete the small, compact office force and management of the Company.

DEVOE & RAYNOLDS COMPANY, INC., stands sixth on a carefully revised list of the oldest American business firms in continuous operation since their inception. It is the outgrowth of the small business in oils, paints, varnish, brushes, and glass established by William Post near the Old Slip Market (later 13 Water St.) in New York in 1754. The progressive character of the Company is indicated by the fact that a trained chemist, James F. Drummond of Boston, was in charge of manufacture as early as 1858.

A number of other companies have been purchased and combined into the corporate structure from time to time to round out the type of service performed by the Company. These include: Wadsworth-Howland Co., 1925; Peaslee-Gaulbert Paint & Varnish Co., 1928; Jones-Dabney Co., 1938; Truscon Laboratories and Beckwith-Chandler Co., 1945; Bishop-Conklin Co., 1948.

The Corporation manufactures paints, varnishes, enamels, lacquers, brushes, artists' materials, and certain cement products, such as roof tile. It markets its products on a national scale to several thousand dealers and distributors and certain Company-owned stores and warehouses. It also exports its products all over the world.

The First World War emphasized our dependence on Europe for many pigments and chemicals. After the war, our country began vigorously to develop our own chemical industry and at the same time the growth of science gave great impetus to the introduction of fundamental scientific principles into business. In the last 20 years the paint and varnish business has become more and more a chemical business. Devoe & Raynolds has contributed greatly to this transition. Among its pioneering contributions are: (1) The two-coat system for painting the exterior of houses and buildings, which has largely obsoleted the former three-coat systems, saving labor and cost. (2) The Dowtherm-heated closed kettles for making millions of gallons of varnishes, alkyds, and other resins to serve as vehicles in flat, semigloss, and gloss wall paints, enamels of all kinds, stains, primers, etc. This type of equipment minimizes decomposition and losses incident to the old direct fire-cooking process and thereby greatly improves many of the qualities of the vehicles. Introduction of science in the cooking of vehicles established on a broad base the groundwork for new and superior qualities in a great variety of products. The finishes on automobiles and refrigerators, Venetian blinds and furniture, etc., are superior today because of it. (3) Automatic machines for the manufacture of paint brushes.

Besides creating entirely new types of coatings, chemical and physical research and development have greatly improved older, well-known types. The Company's Library of Colors now enables consumers a choice of more than 200 different colors or hues by adding small predetermined quantities of one or two-toner colors

to a gallon of paint. This development applies not only to flat, semigloss, and gloss wall paints, but also to enamels and exterior house paint. It is contributing materially to making America more colorful. Research has progressed to where we can now design to prescription and create vehicles and paints as an architect designs a house or building.

In line with this, Devoe fundamental research laboratories spent several years designing and producing an entirely new type of resin made from chemicals (epichlorohydrin and bisphenol). This new resin has many outstanding features. Floor varnishes and enamels based on it dry faster and have greater resistance to abrasion and to scrubbing with water and alkali. The important thing in connection with this new resin is not the specific properties it contributes to some standard products, but the philosophical point that it opens the new era—predetermined design. Devoe has pioneered this step.

DEWEY AND ALMY CHEMICAL COMPANY emerged early in 1919, the result of a life-long ambition of two young officers of the Chemical Warfare Service to start a business of their own. Col. Bradley Dewey and Lt. Col. Charles Almy were friends at Harvard (class of 1908), and both received Ch. Eng. degrees from the Massachusetts Institute of Technology in 1909 and 1910, respectively. From there Dewey had gone to the American Sheet & Tin Plate Co. to organize the first steel corporation department entirely devoted to research. Almy got into the vulcanized fiber business and became a customer of Dewey's for zinc chloride.

From their contacts with industry in producing better gas masks, Dewey and Almy sensed a genuine opportunity for the chemical engineering approach to the problems of industry. Centralized research could put more effort into the problems than any individual user could or would care to do, and do it more efficiently with profit to all. A real field test was provided by the can-making industry, then just beginning to hit its stride, with its need for better sealing compounds. Thus under the laws of Massachusetts, with an initial capital of $120,000, the Company was organized on June 12, 1919, in Cambridge, a place where both men wanted to live. By the end of the year a very modest plant in North Cambridge was ready to operate.

During the early days, Dewey stayed home directing research and supervising production, while Almy went to market. In 1921 Dewey discovered a method of making a sealing compound from natural rubber latex, which was a turning point in the Company's history. As Justice Learned Hand said in a patent suit based on the invention, "It seems to us that not to recognize so substantial an achievement as this which has resulted in the improved preservation of foods and other perishable goods, would deny recognition where recognition most is helpful." It enabled the new company to supply sealing compounds of higher concentration, uniform characteristics, with better aging properties and seaming latitude, which opened new fields for the canning industry.

Having discovered water-base sealing compounds, Dewey and his staff set about developing machines to apply them. This marked another cornerstone in Dewey & Almy policy—supplying a product alone is not enough; a medium to use the product is as essential as the product itself, and a necessary part of the service of a supplier to industry. By constant research, new and improved sealing compounds were made available: by 1926 high-solids compounds for making thick gaskets for sealing glass jars, and by 1932, gasket compounds for steel pails and drums.

In 1925 a plant was built in Oakland, Calif., better to serve the large fruit,

vegetable, and fish-packing industry of the West Coast. This was followed by plants in Naples, Montreal, Melbourne, Chicago, Buenos Aires, and London, each strategically located to serve the food-packing centers of the world.

Prior to 1930 most of the Company's efforts were directed toward developing and perfecting sealing compounds together with latex shoe cements, soldering fluxes, special adhesives, and soda lime. But by 1930 an accumulation of knowledge about the behavior of colloidal dispersions, particularly natural rubber latices, made an expansion program inevitable and practical. The know-how of making mechanically stable latex compounds was used in a process for impregnating fibrous batts for use in shoes and as a base for artificial leather. The treatment of woven fabrics led into the textile print field. Dispersing agents that helped shorten the manufacture of sealing compounds found use as surface-active agents and as catalyst-grinding aids in Portland cement.

Understanding of the action of dormant coagulants led from the manufacture of flexible rubber pails to meteorological balloons, sporting goods, playballs, and toys. This in turn generated a study of the film-forming characteristics of various elastomers which eventuated the Cry O Vac process of packaging frozen foods.

As far back as 1937 Dewey recognized the importance of the newer synthetic rubber polymers, particularly in the event of a war in the Far East. Almy believed that a responsible supplier to industry must always be ready with replacement materials and therefore kept himself constantly informed of marketing developments. By 1939 an organic research division was set up to study this field intensively; by early 1941 a fully equipped pilot plant was producing synthetic rubbers and resins; by June 1942 a full-scale manufacturing plant was in operation in Cambridge. A continuous supply of sealing compounds for the can-making industry was insured, almost the entire output going to the war effort. The demands of the Armed Forces for better products, much as meteorological balloons which were being used under completely new conditions, caused a re-examination of all elastomers. Methods of using synthetic rubbers for the necessary implements of mechanized warfare, were developed, and for this work Dewey & Almy was awarded the Army-Navy "E" four times.

On Sept. 30, 1942, Bradley Dewey was loaned to the Government to serve as U. S. Deputy Rubber Director, to carry out the requirements of the Baruch Report. He succeeded William Jeffers as Rubber Director, Sept. 15, 1943, resigning on Aug. 31, 1944, with the recommendation that the Office of Rubber Director be terminated. As the rubber problems had been adequately solved and future plans well laid, this recommendation was carried out. Upon his return, Dewey, convinced that only the most efficient operators would weather the competitive conditions sure to prevail, made a long-range study of all the Company products. This resulted in the acquisition of a new plant in Adams, Mass., for streamline manufacture of impregnated products for the shoe industry and the textile print field. This plant started in 1945. Later, another plant was built in Acton, Mass., where all the manufacture of flammable materials is centered.

Merchandising of Dewey & Almy products is carried out by trained sales engineers, who first serve an apprenticeship at the main plant. Export sales in countries with no direct representatives are served by a separate sales organization in Cambridge. At one time or another, Almy and his associates have covered by personal calls the leading consumers all over the world. As a result, foreign sales have become a vital factor in the total sales of the Company.

During the early years, it is said that 8% of the Company's sales dollars was spent on research. As diversification of products grew, so did the research effort. Today, a staff of approximately 120 chemists, engineers, and technicians works on

the Company's technical problems and collaborates with customers on theirs. While each branch maintains its own control staff, the main research is carried on in Cambridge. Outside consultants are employed to stimulate and help on various problems as they arise.

The continuing success pattern of the Dewey & Almy Co. has always included additions of brilliant and energetic young men to prevent stagnation of imagination. In 1923 Hugh S. Ferguson, fresh from M.I.T., joined the Company, progressing steadily from office manager to vice-president in charge of manufacturing and finances. In sales, Theodore T. Miller, also from M.I.T., joined the staff in 1922 and played an important role in the marketing of latex sealing compounds. He went to Europe in 1927 to organize the Continental sales of the Company and returning in 1937 as general sales manager, set about building new sales divisions.

Of the first four men hired in 1919, three were chemists. To chief chemist Charles H. Egan, who served with Dewey in the Chemical Warfare Service, can be attributed much of the success for the growth and development of the Company's related research program. A young chemist from Harvard, Henry L. Gilbert, Jr., joined the Company in 1924. In his effort to eliminate the "jungle odors" from early natural latex shipments, he went to the Far East rubber plantations to ferret out the causes and correct them at the source. In 1928 he started the factory in Naples to serve the expanding Italian canning trade and later the Melbourne factory. John A. Lunn joined the organization in 1929 as chief engineer, later becoming executive assistant to Dewey. He handled priorities during World War II and directed the postwar expansion program. All these men have served the Company as directors or officers.

DIAMOND ALKALI COMPANY was born on Jan. 23, 1910, when a group of Pittsburgh industrialists met to form a company to manufacture alkalies. Among them were representatives of alkali-consuming industries. The following May stockholders met to approve articles of incorporation and to elect a board of directors and officers.

A site on Lake Erie near Painesville, O., was selected for the plant, because underlying the area were inexhaustive salt deposits; other advantages were an abundance of cool water, coal within relatively short rail haul, and limestone readily transportable by water. The site also provided adequate transportation by rail and water to the principal consuming markets. Construction of the plant was begun in 1911 and on Feb. 10, 1912, the first soda ash was produced. Before long it was found necessary to increase capacity, which by the middle of 1915 was 800 tons daily.

Part of the new capacity installed was for manufacture of caustic soda, which came early in 1915. During World War I, at the insistence of the Government, the Company doubled its caustic soda production early in 1918. In the fall of 1918 the manufacture of bicarbonate of soda was launched at Painesville. With the initial production of these three basic alkalies from Feb. 1912 to the end of 1918, the first chapter in the history of Diamond Alkali came to a close.

The Company's aim from the outset was to build a completely integrated enterprise, self-sufficient in its principal raw materials and one that would utilize a portion of its alkalies to manufacture other essential raw materials. The latter aim was in part the first to be initiated. Late in 1919 the Company decided to manufacture silicate of soda. A site at Cincinnati was chosen for the plant and by the fall of 1920, the Standard Silicate Co., a subsidiary, began producing liquid forms of this salt. The product contains a rather high percentage of water, so that the freight cost of the water content is an important item to the purchaser.

Economically, therefore, the plants should be located near the principal consuming markets. By 1944 silicate plants were also established in Lockport, N. Y., Jersey City, N. J., Marseilles, Ill., Dallas, Tex., and a fifth was purchased late in 1944 from the Emeryville Chemical Co., Oakland, Calif.

Up to 1920 the Company controlled only its principal basic raw material, the salt beds at Painesville. During 1920 coal lands were purchased and the coal mined by a subsidiary. By-product coke ovens were installed at Painesville in the early part of 1924 to recover ammonia, gas, and tar distillates. A portion of the gas was used for fuel and the remainder sold for domestic heating. Benzene, toluene, and related hydrocarbons are also manufactured by the Company from the tar distillates, and the premium-grade coke for many years has been sold to foundries. During the twenties limestone lands were acquired in upper Michigan as reserves. Quarries were opened at Alpena, Mich., in 1931, from where the limestone is transported through the Great Lakes to the Company's docks at Fairport, O., adjacent to the alkali plant. The limestone completed the integration of the raw material supplies.

At all times Diamond Alkali has endeavored to utilize those end products which might otherwise be wasted. In the manufacture of caustic soda by the lime-soda process a precipitated, free-flowing calcium carbonate of high purity is obtained. To utilize this material the Pure Calcium Products Division was stablished in 1925. The growth of this division led to the development of other types of precipitated calcium carbonates. In 1931 it was expanded to prepare calcium carbonates surface-treated by a patented process and in 1937 the facilities were augmented for production of colloidal-type precipitated calcium carbonates. These various types now reach the market under specified brand names for use in the paint, rubber, textile, paper, and other trades. To turn to account certain limestone screenings not adaptable to use in the alkali process, the Standard Portland Cement Co. was organized and began operating in 1925. Today it is a leading factor in the cement industry in northern Ohio.

Sal soda, lye, and baking soda are packaged for household use by the Buckeye Soda Co., which Diamond organized and built a plant in 1926 adjacent to the alkali plant at Painesville. This is now the only Diamond enterprise catering to the general public. All other lines relate to chemical products for industry.

Toward the end of Diamond's era of integration, 1919-31, two important developments were initiated. With its own salt beds and electrical power, it was a correlative operation to engage in the manufacture of chlorine. An electrolytic plant was put into operation at the Painesville alkali works in Feb. 1929 and expanded several times thereafter. The Company's chlorine output was a major contribution to America's successful prosecution of World War II. The manufacture of bichromate of soda, for which soda ash is an essential raw material, was begun at Painesville in 1931. An expansion of the plant was undertaken in 1944 to furnish additional quantities of bichromate for war purposes.

The manufacture of carbon tetrachloride, chemically 94% chlorine, was begun early in 1933—a further example of the utilization of one of the Company's own products to prepare another for industrial purposes. Expansion of these facilities in July 1941 was of great value in production of war materials.

Practically since its inception, the Company prepared certain alkaline cleansers, but it was not until 1937 that a number of new detergents were developed for specialized uses in the laundry, dairy, and beverage industries. By 1930 and up to the close of 1944 additional lines of specialty cleaners, including laundry soaps, were introduced. To sustain this program an experimental laundry and textile testing laboratory were established at Pittsburgh.

Well-organized departments for purchasing, traffic control, and sales distribu-

tion were established and have functioned effectively throughout the Company's history. Originally individual subsidiary selling companies were maintained in the principal cities, and independent local chemical houses appointed as sales representatives. In the era of consolidation, these selling companies were incorporated into the Diamond Alkali Sales Corp., as branch offices, while the local representatives were retained. In 1938 a Commercial Research Department was established as a statistical agency to aid in planning expanded markets and to follow economic trends. Diamond's research activities were first scattered among the individual manufacturing operations, but in the spring of 1942 all these were merged in a General Research Laboratory.

In the middle of 1941, when the country was preparing for national defense, the Government requested the Company to manufacture metallic magnesium. Since this entails electrolytic decomposition of molte. magnesium chloride, it was necessary to devise a method for the manufacture of magnesium chloride. This was done by an adaptation of the basic alkali process to the treatment of dolomitic limestone. Meanwhile, a plant for the manufacture of the metal, to be operated by the Company as the Diamond Magnesium Co., was built on adjacent property for the Defense Plant Corp., and in operation by Sept. 1942. The plant output exceeded rated capacity and it was not till late 1945 that the operations were discontinued, other wartime magnesium plants having long since closed down.

The Army and Navy demand for high-octane aviation gasoline led to the erection of many new refineries. The new processes requ'ed large quantities of catalysts and to produce one such, a joint venture with the M. W. Kellogg Co., leading engineers and builders of petroleum refineries, was undertaken by the formation of the Diakel Corp. in 1943. In order readily to obtain silicate of soda, the principal raw material, a plant was built at Cincinnati, adjacent to the plant of the Company's Standard Silicate Divisior Diakel Corp. continued to turn out large quantities of petroleum catalyst in the closing days of 1944 and was expected to operate postwar.

An original development by the Company during the war was a synthetic resin made from paraffin wax and chlorine, trade-named Chlorowax This resin was in greater demand by the end of 1944 than the Company could supply for use in flameproofing paints and textiles and in other applications.

Diamond Alkali Co. is constructing a large electrolytic chlorine-caustic soda plant at Houston, Tex., to be completed by the middle of 1948. A portion of the output will be sold, while the remainder will be converted into other Diamond products.

The Company since its inception had maintained headquarters in Pittsburgh, but in Jan. 1947 it was decided to move to Mayfield Heights, a few miles east of Cleveland and southwest of the main plant at Painesville. On this site will be erected a large central office building and a research and development laboratory to house and coordinate the management and development activities of the Company in one location. In anticipation of the ultimate move to Mayfield Heights, the Company moved its general offices from Pittsburgh to the Union Commerce Bldg. in downtown Cleveland, Mar. 1948.

DICALITE COMPANY, when formed in 1929, became the second concern in the world manufacturing a full line of diatomaceous earth products on a commercial basis. Up to that time, 80% of such products was produced by one American firm in an annual volume of approximately 100,000 tons. Dicalite enjoyed a favorable start due to ample financing by two large-volume users of diatomaceous earth.

As business expanded, an active research and development group progressively improved established diatomaceous earth products and introduced new ones. By 1946 the industry as a whole was producing upwards of 250,000 tons per year, of which Dicalite was responsible for a large portion. During that period Dicalite had acquired plant and mine facilities in Terrebonne, Ore., Basalt, Nev., and Kittitas, Wash. These, added to the original plant and extensive holdings near Palos Verdes, Calif., provided high-quality crude resources to support the Company activity for generations.

Fully equipped and modern laboratory facilities were established near Plant No. 1 at Palos Verdes and at Terrebonne. These enabled the Technical Department to keep abreast of industrial demands for fillers, filter aids, insulation, and related items, while maintaining careful, constant control of production at all plants. In this manner a continuous flow of uniform-quality products was assured and the efficiency of all standard items of manufacture improved. Filter aids enjoyed exceptional development and improvement in that flow rates were increased 100% or more, while maintaining equal or better clarity in all grades.

The war activity gave still greater impetus to diatomaceous earth uses. Pressure and vacuum filtration extended into every conceivable industry. Of special importance was the large-scale use of Dicalite Speedplus in drinking water filtration for the Armed Forces. Fillers, too, moved into important places in paper, paint, fertilizer, insecticides, etc.

The original executive staff of the Company was composed of the founder, C. A. Frankenhoff, president and treasurer, and Dr. M. L. Hartmann, vice-president and secretary. Sept. 1930, Dr. Hartmann resigned and was succeeded by A. L. Gossman. In 1938 E. T. Frankenhoff, Central Division manager, was elected vice-president; C. A. Zink, secretary-treasurer; and A. G. Frankenhoff, assistant secretary and Eastern Division manager. July 1943, C. A. Frankenhoff became chairman and Gossman president. Late in 1944 the enterprise was purchased by the Great Lakes Carbon Corp., whereupon Gossman severed his relationship with the industry and C. A. Frankenhoff was selected by the new owners to resume active management of the Company as president. He appointed E. T. Frankenhoff, vice-president in charge of production, and A. G. Frankenhoff, vice-president and general sales manager. On Nov. 1, 1947, these three officers resigned and the Great Lakes Carbon Corp. reorganized Dicalite, making it a division under the general management of Armand R. Bollaert, who had previously been technical director of Dicalite, 1941-46.

DIFCO LABORATORIES INCORPORATED, formerly Digestive Ferments Co., was formed Mar. 25, 1913, to succeed the Ray Chemical Co., begun in 1898, and the Dickinson Chemical Co., established in 1895 to manufacture digestive ferments, particularly pepsin and pancreatin. This organization was probably the first principal manufacturer of pepsin in the United States. Ray Chemical Co. manufactured digestive ferments, developed the manufacture of alkaloids, and established a general line of pharmaceuticals and surgical instruments for private formula and direct sale accounts. With the organization of Difco, the Ray line was discontinued and the business concentrated on the manufacture of pepsin, pancreatin, trypsin, and bile salts to service manufacturing pharmaceutical companies.

An active development program has resulted in two lines of products. The first, an outgrowth of the digestive ferments, consists principally of products of animal origin, such as enzymes and endocrines for pharmaceutical manufacturers; the second, products for bacteriological laboratories. This latter line includes the

culture media ingredients peptones, agar, beef extract, carbohydrates, etc., and dehydrated culture media. More recently, the laboratory reagent line has been augmented by medical diagnostics, such as antigens for syphilis; thromboplastin for the prothrombin time of blood; cephalin cholesterol antigen for liver function tests; and many others. The bacteriological line, developed over 30 years, has originated many materials for routine and research bacteriological tests. These products, trade-marked "Difco" and "Bacto," have been accepted as standard by bacteriologists here and abroad.

The present officers and directors of Difco are: Joseph B. Schlotman, chairman; Harry A. Burnett, Jr., president; Charles G. Predmore, vice-president; David M. Burnett, secretary; W. Ledyard Mitchell, Jr., treasurer; Gustavus B. Pope and Emory M. Ford, directors.

DISTILLATION PRODUCTS, INC., combines the development of a unit process—molecular distillation—and the industrialization of high vacuum, both arising from ingenious experiments begun in the Eastman Kodak Laboratories and developed by the resources and leadership of Kodak and General Mills, Inc., which jointly sponsored the firm during its formative years. In July 1948, Eastman Kodak purchased General Mills' share in the Company and D.P.I. is now a wholly controlled subsidiary of Kodak.

In the late 1920's Kodak had as a technical problem the packing of photographic film under vacuum. The vacuum systems at that time used mercury as a manometer liquid and a diffusion pump fluid; however, mercury vapor ruins photographic emulsions. High molecular weight organic oils (for example, butyl phthalate) could in theory replace mercury, but at this time none of them were pure enough for such use. The research scientists designed vacuum stills which would accomplish this purification, and these first small, glass "molecular stills" were then found to be able to distill practically any animal and vegetable oil. A distillation of cod liver oil to yield a concentrate of vitamin A and D suggested that the process had commercial importance. While Kodak filed patents on the process, it was not immediately interested in the production of vitamins.

General Mills, Inc., which had been manufacturing and selling a few vitamin and pharmaceutical preparations, recognized the need for a good commercial process for the manufacture of vitamin A concentrates and took an interest in molecular distillation. In the early 1930's General Mills entered into negotiations with Kodak which resulted in a joint project being established for research and development in this vacuum field. The project was to help finance its own research by the production of vitamin A to be sold through General Mills. The process itself worked fairly well from the beginning, but considerable difficulties were encountered in the production of high vacuum on a large scale. Fundamental new types of vacuum pumps were invented, and by a coincidence it was found that organic fluids such as butyl phthalate, for which the stills were originally invented, furnished the best operating fluids. After the vacuum technology had been worked out, the distillation of fish liver oils on a pilot-plant scale was carried out successfully. By 1938, having demonstrated its ability to pay its own way, the joint project was replaced by Distillation Products, Inc., with ownership divided equally between the two sponsors, and June 1, 1939, the new company moved into its own plant adjacent to Eastman Kodak. Each year since has seen plant additions till the original building with a floor area of 13,800 sq. ft. (1939) has expanded to about 225,000 sq. ft. (1948).

Molecular distillation is a process by which many substances with molecular weights from 300 to 1,500 can be separated. Thus many "undistillable" materials can be distilled, including fish liver oils, vegetable oils, animal oils, waxes, and tal-

lows, synthetic chemicals, including certain plasticizers, sterols, etc. Molecular distillation occurs in a high-vacuum still designed so that there is no obstruction between the distilling surface and the condenser. Many large commercial units with capacities of 200 gal. per hr. are in use by D.P.I. and other companies. To promote wider use of molecular distillation, the Company has made equipment and licenses available to the chemical industry. It has sought, through the sale of small laboratory units, to encourage the study of these methods by industrial laboratories in a variety of fields. Out of its laboratories have come some 150 contributions to technical literature, ranging from theoretical data on the plotting of speed curves for vacuum pumps to dietary deficiencies in rats. Coupled with its manufacturing facilities and research directly pertaining to them, the Company includes a sizable Biochemistry Department and a large group is also engaged in investigating many problems relating to organic chemistry.

The Vacuum Equipment Division, organized in 1938, started operations with a small technical staff, a metalworking shop, and a glass-blowing department. Originally conceived as a service organization for the manufacture of pumps and accessories for molecular distillation, the unique features of the oil diffusion pumps and accessory equipment which it created soon built up a demand for D.P.I. products, and the Company entered into the vacuum equipment business. This division was accordingly expanded and given a separate sales force. As the distillation process grew up, the Vacuum Equipment Division soon found itself inventing and designing new types of vacuum gauges, valves, and fittings, pump oils and greases, and a host of new products. During World War II, D.P.I. was not only a leading supplier of vacuum equipment, but also had a group of engineers and research people available for work on many vacuum projects. Radar presented a high-vacuum problem, and it was found that D.P.I.'s high-vacuum pumps were one of the most satisfactory units available to produce vacuums sufficiently low at high enough speed to exhaust some of the electronic devices used for radar. The separation of uranium isotopes at Oak Ridge required even larger vacuum pumps which were constructed along basic principles as evolved by Distillation Products' scientists and engineers. No vacuum pumps capable of operating at such high speeds and such low pressures were commercially in use in any other process. Just before the war, it had been discovered that a thin deposition of magnesium salts increased the transmission of light through optical lenses. Midway through the war the Navy ordered that lenses be treated with low-reflection coatings, and before peace other branches of the Armed Service had done the same. D.P.I. vacuum coaters were installed at major arsenals and shore stations, and most repair and service vessels were equipped with vacuum coating units to keep equipment in efficient condition. The Vacuum Equipment Division, in contributing to the war effort, expanded its specialized plant facilities and extended its fund of know-how on vacuum engineering.

Conversion to peacetime production was rapid, since chemical and allied industries are putting molecular distillation to work. Some of the newer plasticizers are being improved by the process; it appears that molecular distillation may have tremendous potentialities in the petroleum field; many new drugs and fine chemicals are now obtainable from natural and synthetic sources by molecular distillation; large installations are being used for refining and purifying edible and industrial oils.

In D.P.I.'s operations, low-potency oils unsuitable for processing by other means are being transformed into highly acceptable pharmaceutical concentrates. Recently (Sept. 1947) the Company announced the synthesizing of vitamin A by a process which will make the synthetic product commercially available for the first time. In time, it is expected that the new product, called "Myvax" Synthetic Vitamin A, will replace the bulk of the natural product. For the present, it will serve

to alleviate the critical shortage of this important dietary factor. Another oil-soluble vitamin, vitamin E, is also produced by molecular distillation from natural vegetable oils. Although it has been synthesized, the process is a costly one, so that the natural product brings within reach of many a vitamin of increasing usefulness.

Distillation Products, Inc., is now completely owned and controlled by the Eastman Kodak Co. Its board of directors is made up of C. E. K. Mees, R. W. Albright, C. J. Van Niel, Donald McMaster, I. L. Houley, and G. C. Mees. Its officers are C. E. K. Mees, chairman of the board; McMaster, president; Albright, vice-president and general manager; G. C. Mees, vice-president in charge of sales; M. K. Robinson, secretary; J. L. Harper, treasurer; Van Niel, comptroller; J. C. Hecker, works manager; N. D. Embree, acting director of research; R. T. Sullivan, assistant treasurer and assistant comptroller; W. F. Shepard, assistant secretary; and H. S. Woodruff, assistant secretary.

DISTILLERS CORPORATION-SEAGRAMS, LTD., one of the most consistent company developments, has been due to undeviating adherence to a policy based on long-range planning and blue-printed organization. "Seagramerica," as the far-flung Seagram business is known, had its beginnings in 1857, in the frontier settlement of Waterloo, Ont. The first distillery was a little flour mill called Granite Mill, whose chief purpose was to grind grain for near-by settlers. As was customary, some of the grain left as payment was used in distilling, and sometimes those who brought in grain preferred to take it back in liquid form. Joseph E. Seagram, miller and distiller, pioneer and individualist, had $10,000 invested in the Granite Mill; his employees numbered 15. In contrast, sales for the fiscal year 1945-46 totaled $400,054,519; the net profit $13,803,800. Today approximately 11,750 persons are employed in the organization. The parent company is led by the Bronfman brothers, Samuel, who is president, and Allan, vice-president, and the Bronfman family owns 53% of the common stock.

In 1925 the Bronfmans had just erected their first distillery in Montreal and their every business move was made with one eye to the end of Prohibition. Three years later they acquired Joseph E. Seagram's business, which had been growing quietly, and changed the name of their own Distillers Corp., Ltd., to Distillers Corporation-Seagrams, Ltd. From 1928-33, the sales of Seagram brands in Canada reached 40% of Canadian totals. On the very first day of Repeal, the Bronfmans began to distill whisky in their first United States plant in Lawrenceburg, Ind., which had been in existence some 147 years and had an average daily capacity of 58,000 gal. neutral spirits. In May 1934 a second United States plant was purchased at Relay, Md., and other acquisitions steadily followed. The result has been a complex structure of subsidiaries, the leading affiliates, in addition to Joseph E. Seagram & Sons, Inc., being the Calvert Distilling Co., Carstairs Brothers, William Jameson & Co., Frankfort Distilleries, Inc., and Hunter-Wilson Distilling Co. Together these companies market 24 whiskies and six gins.

Headed by the parent company, management is by officers and directors, many of whom have held administrative positions in other commercial and industrial fields. Samuel Bronfman heads the parent company, with Allan Bronfman, H. Frederick Willkie, and James E. Friel as vice-presidents and directors; A. M. Henderson, secretary-treasurer; and Herbert P. Brown, comptroller. Other directors are Harvey D. Gibson, T. H. McInnerney, Frank R. Schwengel, J. Alex Prud'homme, J. E. Frowde Seagram, and W. W. Wachtel. General Schwengel is president and director of the American affiliate, Joseph E. Seagram & Sons, Inc.; Willkie is vice-president and director; James E. Friel, vice-president, treasurer, and director; Joseph G. Friel, secretary, assistant treasurer, and director; Brown, comptroller. Other directors are Victor A. Fischel, Ellis D. Slater, and Wachtel. Since 1937,

during the years of expansion in the United States, all plant operations have been under Willkie, vice-president in charge of production for all Seagram marketing affiliates.

Seagram's United States distilleries have a daily capacity of 47,000 bushels of grain, equivalent to production of approximately 235,000 U.S. proof gallons of beverage alcohol. The Company's newest plants are at Louisville, Ky., with four distilleries and six smaller plants within a radius of 90 miles. In Indiana is the famous Lawrenceburg property with a mashing capacity of 11,500 bushels a day. Other large properties are located in Baltimore and Relay, Md., with smaller, active plants in Ohio and Pennsylvania. Canadian distilleries are located in Montreal, Waterloo, Amherstberg, and Vancouver.

In June 1937 a Research Department was established when it became evident that the distilling industry needed technical improvements and modernization. The primary objectives were, first, to institute a high degree of technical control over raw materials, processes, and products; second, to initiate a long-range program of process improvements, including by-product recovery and development. By 1941 rigid specifications for raw materials and supplies had been developed, and daily plant operations had been placed under full physical, chemical, and bacteriological control. Rapid strides had also been made in process improvement, one of the most significant being low-temperature, high-vacuum beer distillation installed in 1939.

By the spring of 1941, laboratory and pilot-plant development work had been completed on the continuous-cooking, flash-conversion process for gelatinization of grain starches and for their conversion into fermentable carbohydrates. By the fall one commercial plant was in operation whose net effect was to reduce the time of grain processing from whole grain to fermenter from four and one-half hours to five minutes; cut down equipment and capital investment; increase the yield 2%; and save steam and power. A continuous, pure-culture aerobic process of producing distillers' yeast was completed by Oct. 1941, but the war intervened and subsequent developments eliminated necessity for the process.

Two years of intensive laboratory work had been spent on developing a fast, continuous fermentation process. As emergency demand for alcohol increased in 1941, these data were successfully applied to alcohol production from molasses. In keeping with Seagram policy, by the spring of 1942 all data relative to continuous fermentation had been presented before accredited technical societies. This was at a time when molasses alcohol plants in the United States were faced with the necessity of immediate conversion to grain as raw material. Seagram research and engineering staffs cooperated wholeheartedly with the industry in utilizing these findings. They continued study of the production of alcohol from grains, so that when corn became unavailable, Seagram led in the use of new raw materials, such as wheat, granular flour, sweet potatoes, potatoes, and sorghums such as milo and Kafir. During the war Seagram produced and sold to the Government for military purposes 263,668,083 gal. industrial alcohol.

With the advent of war, a large part of the research program was devoted to new means of producing natural rubber and butadiene. Through Seagram efforts, a report was sent to the National Farm Chemurgic Council in Sept. 1941 on the possibility of obtaining kok-sagyz seed for experimental planting in this country. By 1942 the seed had been delivered by plane from the Soviet Union. The succeeding two and one-half years were spent in designing a fermentation process for the production of 2,3-butyleneglycol and its conversion to butadiene. Through Seagram initiative, a cooperative project between government laboratories and many private companies was established at a conference at the Northern Regional Re-

search Laboratory, Peoria, Ill., in Apr. 1944. With its own resources the Company completed a special pilot plant for development of the process on a semicommercial basis; June 1944, capacity was one ton of butadiene a day. This project received a favorable report from the Rubber Reserve Board, but since additional butadiene production was not needed, a commercial unit was never authorized.

In 1939 Seagram research increased emphasis on recovery and utilization of by-product materials for animal and poultry feeds. This work was an important factor in the nation's wartime food economy. Several supplementary university fellowships, now broadly expanded, were established, with the result that distillers' dried solubles replaced skimmed milk powder in many poultry rations. By 1944 this research was extended to food products for human consumption. Intensive laboratory work produced a high-protein content food supplement, a yeast and protein hydrolysate, and a mixture of pure, naturally occurring amino acids.

The crucial petroleum situation in various parts of the world, emphasized during wartime shortages, focused attention on agricultural alcohol for fuel, especially in some of the smaller nations. Improvements in processes and methods of alcohol production, reported by Seagram researchers, led several countries to approach the Company for technical information. Some requested that their personnel be trained in the methods developed, and from these contacts evolved a program for training international fellows. As now organized, it accepts college graduates under 30 years of age for a year's training and observation. The trainee may then use his knowledge in his own country. Seagram designed a mob .e agricultural alcohol unit which was demonstrated at the National Chemical Exposition at Chicago, in the fall of 1946.

Since the war, extensive investigations have resulted in a basis for improved barley malt specifications and development of a new process for the submerged culture of fungal amylase. The latter process greatly reduces the cost of starch conversion and is part of the over-all development of the continuous fermentation of grain mashes. Further advances have been made in the distillation of alcohol to produce higher-quality neutral spirits through the development of the cascade-type, high-vacuum beer still and improvements in the rectification system.

Since the industry operates on agricultural raw materials and since the by-products return largely to the farm, an effort has been made to maintain good relations with the farm community through various agencies and associations dedicated to improving livestock, crops, and general farm conditions. The Corporation maintains a farm where experimentation is constantly under way to improve agricultural economy. Furthermore, fellowships are offered to Seagram employees so that the Company's knowledge on specific problems can be broadened. Nearly 100 men from other countries have participated in the international fellowship program at Seagram plants, and several employees have been sent to foreign countries in student and advisory capacities. The philosophy directing this activity is based on the belief that industry, as well as government, has a world-wide civic responsibility.

DORR COMPANY, with its world-wide activities, is very much the lengthening shadow of its founder and president, John Van Nostrand Dorr, and of his inventive genius. Born in Newark, N. J., 1872, Dorr was educated in private schools and graduated from Rutgers in 1894, with a B.S. in chemistry. Prior to college, he worked two years directly under Thomas A. Edison as a chemical experimenter.

After a short period of industrial chemical work in the East after graduation, Dorr went West to become chemist at a smelter at Deadwood, S. D., in the Black

Hills. This was a period of great developments in metallurgy, when the refractory gold ores of "The Hills" were being treated by smelting, chlorination, and the newly developed cyanide process. Dorr left the smelter to learn more about the latter process, and, after a short time in Colorado, returned to Deadwood, where in 1902 he formed a partnership with John Lundberg, a mine leasor, to operate a cyanide mill, the Rossiter Mill, to treat gold ores from Lundberg's two leaseholds, the Buxton and the Bonanza Mines. In 1903 the partners purchased the two mines, erected a 100-ton per day wet crushing cyanide mill on the site, and took in a third partner, A. D. Wilson, a civil engineer. At the Lundberg, Dorr & Wilson mill, Dorr tried out the new Moore filter process, a large cone for the continuous collection of slimes, and a Chile mill in place of the stamps used in the district. To effect a clean-cut separation between fine slimes and coarse sands prior to separate cyanide treatment, the Dorr classifier was developed, patented, and arrangements made for its manufacture.

In 1906 Dorr was engaged as consultant on the remodeling of the dry crushing mill of the Mogul Mining Co., which was having trouble with slime collection. He conceived the idea of continuous slime thickening in flat-bottomed tanks and developed the first Dorr continuous thickener. In 1910 came the Dorr agitator and later two new principles: continuous countercurrent decantation and closed circuit grinding. The engineering principle underlying these inventions was that mechanical means were necessary for most efficient continuous handling and treatment of finely divided solids suspended in liquids. Manufacturing arrangements were made in Denver and Chicago and Dorr began to build an engineering organization to market his inventions and the engineering services that went with them, while continuing to manage two mining properties in the Black Hills. In 1910 the Dorr Cyanide Machinery Co was formed to become in 1916 the Dorr Co., Engineers.

Interests had been given to various associates at the beginning. Among these was William Russell of Glasgow, who came to the United States for the McArthur-Forrest Co., patentees of the cyanide process. He joined Dorr in 1911 and made a trip that year to South Africa for the Company, later becoming head of its London associate, Dorr-Oliver Co., Ltd., from which he retired as chairman in 1946. Luther Eames, who assisted in the development of the thickener in 1906, is still a stockholder and associated with one of the companies manufacturing Dorr equipment. The late H. Norman Spicer made the first trip around the world for the Company in 1911-12. Edwin C. Reybold, an early Black Hills associate, is still with Dorr Co.; Elmer R. Ramsey, who joined in 1914, is operating vice-president and a director. Zay Jeffries, who worked with the classifier in 1904 while still an undergraduate, has become a distinguished scientist in other fields and a vice-president of the General Electric Co. Another early associate of the classifier development era, Edward Johnson, nephew of John Lundberg, was on the staff at the Westport, Conn., Laboratories until his death in 1947.

The technological developments in ore dressing and wet metallurgy during the 1920's greatly increased the demands for Dorr machinery and engineering services in this country and abroad. A territorial growth began. The first commercial office was opened in Denver in 1907. In 1913 Spicer left Denver to open a one-room office in New York, which later became headquarters. Branch offices followed: Chicago, 1922; Los Angeles, 1923; Toronto and Atlanta, 1926. The first European office was opened in London, in 1912, in charge of Russell. The same year Edward L. Bateman, Johannesburg, became Company representative in South Africa and Rhodesia. Later came offices in Paris and Berlin, 1925; Brussels, 1930; The Hague (now Amsterdam), 1931; and Milan, 1937. Except for Berlin, these cities are headquarters of the five Dorr-Oliver Companies, wholly owned

subsidiaries organized under the laws of their respective nations, which both manufacture and market products of the parent company and of Oliver-United Filters, Inc., San Francisco.

The Company has had representatives in Mexico City since 1908; Melbourne, Australia, 1911; Rio de Janiero, 1920; Buenos Aires, 1924; Tokyo, 1929; Caracas, Venezuela, 1946. In addition, its Petree & Dorr Division, operating exclusively in the cane sugar field, established representation in Havana, 1920; Hawaii, Puerto Rico, and the Philippines, 1923; India, 1933; Mexico, 1941; Colombia, Mozambique, and Angolia, 1942.

Originally the Company's business was related directly to the cyanidation of gold and silver ores in this country and in Mexico. The iron, lead, copper, phosphate, and sand fields were also entered in a small way. Ultimately not only all of wet metallurgy, but also most of heavy chemical and industrial processing, sugar manufacture, and sewage, water, and trade-waste treatment became Dorr customers.

An early application in the chemical field was in the continuous manufacture of caustic soda by the lime-soda process. Closely related to cyanide treatment, the causticizing reaction took place in a series of agitators, sedimentation and washing in a series of thickeners, while a classifier at the head of the system removed inert materials from the milk of lime. The same principles were subsequently applied to the manufacture of phosphoric acid by wet methods, aluminum sulfate, alumina and magnesium, barium sulfide, lithopone, and titanium pigment, and many other chemical products.

The preparation of finely divided water-floated clays, pigments, and abrasives by continuous methods opened up another broad field for the classifier and thickener. The wet process cement industry changed from open to closed circuit grinding. Practically all sulfate pulp mills standardized on the Dorr continuous recausticizing system. In the beet sugar industry the Dorr continuous first carbonation process and the lime mud thickener were installed in over three-quarters of the North American producing capacity, while the Dorr de-ionization system is increasing sugar yields. The cane sugar field is a broad user of the Dorr cane juice clarifier and Oliver-Campbell filter.

The loan in 1914 of a small experimental thickener to Chicago's Sanitary District led to a vast new field which in normal times amounts to about one-third of the Company's business. The initial objective was the continuous clarification of domestic sewage. The clarifier, an adaptation of the thickener principle, proved to be the solution. Intensive studies of this new field resulted in the development of a complete line of special equipment, which has been found to be directly applicable to the treatment of municipal sewage and water supplies, and to liquid industrial wastes and sources of process water.

The three original machines, produced with only a nominal development cost, have been expanded to over 30, of which there are over 75 different types. However all are inherently based on the same fundamental principles involving classification, sedimentation, and agitation.

The Westport, Conn., Mill acquired in 1917 and equipped to carry out all the Company's research and testing, supplanted two earlier, small test plants in Denver and New York. A modern research plant was built in 1937 on the foundation of the old one destroyed by fire, and in 1944 a pilot plant was added. Care was taken to preserve outwardly the lines of the original mill building, dating back to the Revolution, the beauty of the site, and the atmosphere and environment in which it had been found that the research man thrives and produces at his best.

At Westport, aptly called the "Dorr workshop," a complete integrated technical service operates in collaboration with the Company's Consulting Engineering De-

partment for carrying a new project through research, pilot-plant, and design. Many clients with well-equipped and well-staffed research facilities bring their solid-liquid phase problems to Westport for solution. Likewise the Company has frequently taken its problems to university and independent research laboratories. A research fellowship at Rutgers University established many fundamentals underlying the art of sewage sludge digestion. Another at the Mellon Institute yielded the basic facts governing the flocculation of ultrafine solids in sewage, water, and chemical solutions. A third at the University of Minnesota led to major improvements in methods of grinding and blending the raw materials of wet-process cement manufacture.

Work of this type, plus the fact that, basically, the Company's business is the solving of technical problems, has led it into the development of new processes just as much as into purely equipment development. Whereas only 37% of its last 500 United States patents relate to processes, the ratio has increased to 67% among the last 100 of these.

It has never been the Company's policy to own its production facilities as its products are so varied that they can best be made in jobbing shops. Furthermore, patents and other considerations require great flexibility. Manufacturing has also been carried on in this same manner by its European associated companies, and in some instances by its other representatives outside the country.

On the Company's staff are many with long years of service. Two from the Black Hills days are still active in the Company, and two others have only recently retired. In 1946, of the domestic staff of 350, 47% had been with the organization 5-10 years; 10% for 10-15 years; and 6% for more than 25 years. Furthermore, the six members of the executive committee, all officers, averaged 27 years of continuous service and 11 on the operating committee averaged 23 years.

Dorr is president and chairman of the Company and of Dorr-Oliver Co. His brother, Goldthwaite H. Dorr, assistant to Assistant Secretary of War Crowell, and Secretary of War Stimson during both wars, is vice-president and general counsel. Elmer R. Ramsey is operating vice-president; Frank A. Downes, vice-president, research and development; H. E. Haws, treasurer; J. Delano Hitch, vice-president, sales; Douglas C. Reybold, secretary-controller; and Arthur Terry, Jr., vice-chairman of the board, Dorr-Oliver Co.

Two things have characterized the Company from the very beginning: world-wide interests and the recognition that its function is to solve problems or render engineering services, whether in the form of specialized equipment, plant design, or research, or all three. Its equipment was originally developed by its founder while managing properties to meet needs, and its early work featured plant design with one case of erection and management operation. The almost unexpected growth of the whole business led to the development and marketing of equipment becoming its principal function. Its original engineering approach, with the commercial influence in the background, has probably made it less of a financial, but more of an engineering success than it might otherwise have been.

Currently, the Company's 12 most active fields are: cane and beet sugar, pulp and paper, municipal sewage and water, cement, gold and silver, sand and gravel, phosphate rock, industrial water, iron ore and copper. They yielded over three-quarters of the dollar volume of orders entered in 1947—a year in which over one-third of the business came from abroad.

John V. N. Dorr has been many times honored by the metallurgical profession for his contributions to the arts of ore dressing and hydrometallurgy, and by the chemical engineering profession for his contributions to their problems of low-cost mass production. In accepting these honors, he has bestowed a large measure of

the credit upon his own professional associates and the Company that has brought practical realization to the ideas which he originated.

DOW CHEMICAL COMPANY had its real beginning in the spring of 1888, when Herbert Henry Dow, a senior at Case School of Applied Science, Cleveland, located an abandoned gas well at near-by Canton that brought forth nothing but brine. The owners engaged him to give them a complete analysis of this brine; whereupon the young student reported it contained bromine with traces of iodine, strontium, ammonium, and lithium together with ordinary brine components. The following year, while teaching chemistry and toxicology in the Cleveland Homeopathic Hospital College, Dow secured a patent on extraction of bromine from cold brine involving passage of an electric current of low voltage through the brine, followed by blowing air through the reddened brine to liberate the bromine in vapor form and subsequent absorption of bromine vapors. The process had a practical trial at the Canton well, but this brine was so corrosive to the piping system that all had to be abandoned late in 1889.

On Aug. 12, 1890, Herbert Dow visited Midland, Mich., to study the problem at close hand. Though production of bromine in the United States was first undertaken in 1825 at Natrona, Pa., and had extended to southern Ohio, the third location at Midland had taken the leading position in this country. Dow observed that the low cost of evaporating brine lay wholly in waste slab wood from near-by sawmills and must needs end with the disappearance of the mills. Hence his blowing-out process requiring no evaporation of brine should be ideal for this locality. It was also apparent that the older process, in removing the crude "grainer" salt before extracting bromine from the mother liquors, or "bitterns," was certain to glut the market with salt. Here, again, the Dow process offered the only procedure capable of procuring bromine without any necessity of producing crude salt except as desired.

Returning to Cleveland, Dow convinced a group of his friends of the feasibility of this project. A partnership was formed as the Midland Chemical Co. and leased a well at the northwest end of Main St., Midland, thereupon proceeding to manufacture ferric bromide solution which had ready sale but was not highly lucrative. In fact, there was urgent need for more capital. Accordingly, Aug. 17, 1892, this partnership became a corporation of the same name under the laws of Michigan and some $19,000 paid-in capital. Two new wells were drilled adjacent to the old sawmill within the present plant boundaries. Directors were J. H. Osborn, National Carbon Co., Cleveland, and W. B. Helman, another Clevelander; W. W. Cooper, and two Midlanders, W. B. Remington, a mill operator, and conveniently, a well driller, Thomas Percy.

As general manager of the Midland Chemical Co., Dow soon directed his efforts toward the manufacture of potassium bromide crystals, the potash being secured through leaching wood ashes from sawmills. After many tribulations, a potassium bromide of highest grade was placed on the market, the first lot being sold to Rosengarten & Sons, Philadelphia, in 1893. About this time a product known as "mining salt" was developed by the Company for use in the extraction of gold ores. It was a natural product of production, since it contained one part of alkali bromate to five parts of alkali bromide. For many years these mining salts were shipped all over the world and the present Dow Diamond trade-mark originated with the identification of the mining salt packages for export shipment.

So successful was the electrolytic separation of bromine from raw brine that production of chlorine was contemplated, following removal of the bromine, by applying a current of slightly higher voltage. In 1893 a semiplant for chlorine was

set up, but its disappearance by explosion discouraged the majority of the directors. Herbert Dow was not so easily discouraged—in fact never discouraged. He was convinced that the causes of the chlorine explosion could be eliminated. To this end he moved to Massilon, O., and in 1895 formed a new partnership, the Dow Process Co., with the support of James T. Pardee, a classmate, Cady Staley and Albert W. Smith of Case, and his original backer, J. H. Osborn. This company opened a little plant at Navarre, O., where cheap salt and power were available. Dow soon realized that chlorine could be made more cheaply from Midland brine, so he returned to Midland to construct a small plant for this purpose. By the close of 1896 the feasibility of the process for bleaching powder production had been demonstrated.

The Dow Process Co. chlorine cell was bipolar, as was the bromine cell, but with an inverted trough over the anode compartment to serve for draining off the chlorine and to prevent any hydrogen mixing with it, leading to explosions. In the United States the Dow cell was the first to produce bromine and the Le Sueur cell the first to produce chlorine.

May 18, 1897, a new company was incorporated in Michigan as the Dow Chemical Co. The president was Albert E. Convers of Cleveland (this position he occupied to 1918, when he became chairman until his death in 1935). Other officers were: 1st vice-president, S. T. Wellman; 2d vice-president, G. E. Collings; secretary-treasurer, Charles A. Post; general manager, Herbert H. Dow; on the board with these men were Dr. Staley, Dr. Albert W. Smith, Pardee, Osborn, A. L. Fuller, and William L. Baker. Thus did the present Dow Chemical Co. come into being with a capitalization of $200,000, an initial paid-in capital of $20,000, and its objective chlorine and bleaching powder. The new company took over the assets of the Dow Process Co. and, across the street from Midland Chemical, built its plant for production of chlorine to be directed immediately into manufacture of bleaching powder. From this small start, this same company has long since attained the position as America's largest chlorine producer. The capacity of the new plant was nine tons of bleach per day, making use of bromine-free waste liquors from the Midland Chemical Co. The enterprise showed promise. Simultaneously with Dow Chemical, the Castner-Kellner Co. of Niagara Falls, N. Y., entered the manufacture of bleach. Both were able to meet competition with English bleach. With interests and raw materials so much in common, in 1900 Dow acquired the assets of Midland. The same year the bleaching powder plant was doubled in capacity and again doubled in 1901, and the whole doubled in 1902 to a capacity of 72 tons a day. The entire project was developed under Herbert H. Dow, Thomas Griswold, Jr., and Fred N. Lowry.

Bleach was the first of several Dow products for which the United States had been largely or entirely dependent upon foreign sources, among them indigo, iodine, and magnesium. It led to Dow's first battle with foreign interests who, seeing a large chunk of their American market slipping away, began a price war in 1903. Since Dow had started production, the price of bleaching powder had already been brought down from $3.50 to $1.68 per hundredweight. The price battle slashed it to 87¢ per hundredweight. Dow hung on tenaciously but would undoubtedly have fallen before its older and wealthier foes had it not been for a tariff at four-tenths of a cent per pound. In 1905 the challenger gave up the fight and the price settled at $1.25 at which rate Dow could operate profitably.

Keen competition in bleaching powder made all the more necessary a search for increasing uses of bromine. Then an oversupply of chlorine developed and new adaptations again were called for. Some directors at this time delved into the possibilities of organic halides. In 1902 they organized the Midland Chemical Co.

(the second) which introduced the first commercial synthesis of chloroform from carbon tetrachloride and sold the product commercially in 1903. As one of the first synthetic organic chemicals manufactured in the United States, it was made possible through the invention of a director, Dr. Albert W. Smith of Case, who brought the reducing action of iron and water to play upon carbon tetrachloride in closed vessels. It was first necessary to prepare sulfur chloride and then interact it with carbon disulfide in the presence of iron, when carbon tetrachloride distilled off. Though carbon disulfide was at first purchased, its production was soon undertaken. In 1914 the second Midland Chemical was absorbed by Dow.

Dr. Edwin O. Barstow, who came to the Company in 1900, was largely responsible for getting the chloroform process into commercial operation; later Dr. Charles J. Strosacker expanded it. Production continued in steady volume and with periodic improvements for 40 years, when the process was finally obsoleted by a direct chlorination of methane process developed by Dr. W. Hirschkind and associates of the Great Western Division. This chloroform project also had growing pains. There was a healthy market for chloroform in the pharmaceutical field, but carbon tetrachloride and sulfur chloride were not similarly blessed. There was talk that the former might be a good dry-cleaning agent but no apparent market interest. The Company had no salesmen, such matters being handled by Dow himself or other executives. There was, however, a young bookkeeper who had joined the organization in 1900: Earl W. Bennett, today the firm's treasurer, a vice-president, and director. Looking through the premium book of the old Larkin Co., Bennett noticed a "non-inflammable dry cleaning fluid" among the listings. Suspecting this might be carbon tetrachloride, he wrote Larkin and as a result cleaned out Midland Chemical's entire stock of the material—five drums. Thereafter markets for the solvent gradually opened up. Today it is one of the Company's most substantial products with almost numberless industrial uses. It is perhaps best known to the public as a fire extinguisher, but it is almost as prominent a dry-cleaning fluid and industrial solvent. The third organic chemical produced was benzoic acid, in 1904.

A serious situation arose through Dow's offering of bromine in foreign markets. Dow was en route to California with his family in Jan. 1906 when he was stopped in St. Louis by a frantic wire from the Company's agents in New York. One Herr Jacobson, it said, representative of the German Bromine Convention, was in New York and it was imperative that Dow come there at once. Dow was for continuing his trip, but on the plea of several customers finally agreed to wait over a day in St. Louis if Jacobson would come there. Herr Jacobson arrived and explained that it could not be permitted for America to sell chemicals in German-controlled markets. If it were not stopped immediately the German Convention would ship two pounds of bromides into the United States for every pound Dow chose to ship abroad. "That," replied Dow, "is up to you, and I don't see that we have anything further to discuss."

Though Jacobson insisted upon further conference, the Dows left that evening for California as planned. Dow had not been through the battle of bleaching powder for nothing. He wired Midland to start selling bromides on both domestic and foreign markets as fast as possible and without regard to price. Thus getting the jump on the German combine with a large backlog of orders, the Dow Chemical Co. was ready to fight. It looked like an international game of David and Goliath, but while "David" did not have the U. S. Government as a "partner," he did have a government that had long seen the wisdom of encouraging and protecting its young industries. The tariff of 2¢ per pound was of great help. The bromide war lasted three years; the price at one time being as low as 10¢ a pound. Dow parried

the German attack with its own weapons. As fast as they undercut Dow's prices in the United States, Dow undercut German prices in Europe. Finally early in 1909 the Germans withdrew from the American market. Dow continued to export bromides all over the world and has done so ever since except during the two Great Wars. For further supply of bromine the Company in 1903 drilled several wells at Mount Pleasant (26 miles west of Midland).

A sales department was organized in 1904 with Rupert E. Paris as first manager. Following Paris in the fall of 1909 came W. H. Van Winkle, then in 1917 G. Lee Camp, who remained in this position until 1929, when Leland I. Doan took over. In Sept. 1945, Doan, vice-president, secretary, and director, became director of sales, and Donald Williams was appointed general sales manager.

In taking over Midland Chemical II, Dow Chemical found itself in need of diverting to some new field the waste sulfur left over when chlorine and sulfur are made to react. Lime sulfur, most valuable for dormant spraying of fruit trees, came into the picture. At the same time the waste ferrous chloride, resulting from the reduction of carbon tetrachloride to chloroform, found use in the production of ferric chloride for etching printing plates. Chlorine was directed to the oxidation of arsenious oxide to arsenic acid, which was prepared and sold in the form of lead arsenate and Bordeaux mixtures, thus enlarging the Dow field of insecticides as well as increasing the use of chlorine. In 1910 production of carbon tetrachloride topped 100,000 lb. per month, thus making way for the by-products that built up the Agricultural Chemicals Division, embracing more than a score of products ranging from the two original insecticides to plant hormones, weed killers, and soil fumigants. Much of this work was fathered by Dr. Strosacker, Ivan A. Kenaga, Robert R. Dreisbach, and Edward C. Zuckermandel, with Joseph A. Cavanagh as manager of the division and more recently Dr. Don D. Irish organizing the Biochemical Research Laboratory, with which are also associated Dr. Edwin E. Dunn and George E. Lynn.

As early as 1907 the Company was considering the calcium and magnesium salts that occur in brine as such. Research evolved three magnesium compounds—the carbonate, chloride, and sulfate (Epsom salt). The first enjoyed a moderate medicinal use but was not an outstanding sales success. The latter two developments, however, were fortunate in that as the Epsom salt and magnesium chloride plants were completed, World War I broke out in Europe. Imports of these important chemicals were cut off and Dow found a ready market. Epsom salt was needed as a pharmaceutical and tanning agent, while magnesium chloride became highly important in stucco and oxychloride flooring. Predominant in these developments were Dr. Barstow, Earl R. Stein, Dr. William R. Collings (now general manager, Dow Corning Corp.), Leroy C. Stewart, Clarence C. Rose, and Sheldon B. Heath. In the same manner, calcium chloride was offered about 1914.

During World War I a branch of Edgewood Arsenal was established at the Dow plant to manufacture mustard gas and other needed chemicals. Furthermore, war demands for the explosive, trinitrophenol, impelled the Company to take up the manufacture of synthetic phenol by the old benzene-sulfonation process. Some 40 tons of phenol soon constituted the daily output. In this largest-till-then organic chemical undertaking, the services of Dr. Barstow, Thomas Griswold, Jr., Paul Cottringer, and Boyd H. Carr were highly contributive. With phenol in production it was a short step to salicylic acid, aspirin, and a host of salicylates. Dr. Mark E. Putnam fathered these steps with able assistance of Clarence C. Rose, John McCreadie, and considerably later, J. Walter Britton. By 1916 the Company was well launched in the pharmaceutical field.

The rapidly diminishing stocks of dyes presented an opportunity for Dow

Chemical to enter the synthesis of indigo—primarily in hopes that eventually a demand for the beautiful brominated indigos would create an outlet for increased bromine production. To make indigo, the intermediates aniline and chloroacetic acid were needed, which should be produced at home, and Dow Chemical was launched in the dye industry through the perseverance of its founder, together with Dr. Lee H. Cone, Dr. Strosacker, Chester C. Kennedy, Earl Pelton, Rex Ward, Harold S. Kendall, Howard J. Rupright, Clare C. Schwegler, and Joseph C. Gindlesperger. In good time the first batch of synthetic indigo was produced in the United States and the first sale made, Jan. 1, 1917, to Proximity Manufacturing Co. of Greensboro, N. C.

When production of magnesium chloride attained reasonable proportions, research was under way to isolate metallic magnesium through electrolysis. In this effort several corporations displayed keen interest. At the Dow plant 1916 records the first appreciable experimental output. But following the war intensive efforts were put forth by Dr. Dow and a large group composed of Dr. William R. Veazey, Dr. Barstow, Edward C. Burdick, Louis E. Ward, and somewhat later Ralph M. Hunter, Dr. John A. Gann, John E. Hoy, Arthur W. Winston, Dr. LeGrand Morell, Dr. J. Donald Hanawalt, and Charles E. Nelson. By 1927 Dow found itself the only remaining producer of the metal in the United States.

Active fabrication development on the part of both Dow and American Magnesium Corp. led to a great number of patents individually held by each concern. Since some of these were essential to the growth of the industry, cross-licensing of such alloying and fabrication patents was logical. This move, which permitted the magnesium industry to go forward in this country unrestrained in any way, was later interpreted by the Department of Justice as a "monopolistic" endeavor and resulted in an indictment against the Company in 1941. Dow was subsequently cleared by the Truman Committee, with the entire story set forth in a booklet, *Dow and Magnesium*, published in 1944 by the Dow Chemical Co. During these years vast sums were spent in the development of alloys and fabricating methods to make the metal usable despite a barely lukewarm industrial interest and no interest whatever on the part of the Army and Navy. Of great importance was the well-equipped Spectroscopy Laboratory under Dr. Norman Wright, director, and Dr. Ludo R. Frevel as special investigator. Yet when World War II imposed its ravenous demand for magnesium not only for incendiaries but for aircraft parts, it found Dow ready with the production and fabrication knowledge needed to send this metal effectively to war. Dow had been sufficiently foresighted to more than double its productive capacity 11 months before Pearl Harbor with a Gulf Coast plant to extract the metal from the inexhaustible ocean.

While World War I had tremendous influence on the American chemical industry, it by no means represented its birth, since there was a very considerable inorganic chemical industry. The early part of the war placed upon American industry the responsibility for producing those goods formerly standard commodities of import generally used in this country, but not produced here. In this respect the war was a stimulation to the growth of the industry. However, as in all wars, production had to be developed which was not useful in peacetime. Dow's enormous phenol plant—which was enormous for those days—was shut down immediately and entirely scrapped; likewise the cellulose acetate and aluminum chloride plants. The greatest postwar stimulation for further growth of our chemical industry was the Fordney-McCumber Tariff which permitted the industry to grow, unfettered by foreign competition. Increased demand for American-made chemicals was more than anticipated and many new processes were perfected which would otherwise have taken many more years of development. As a typical

example of this in the Dow Chemical Co., the demand for phenol became sufficiently large through its use in the manufacture of salicylic acid and other products to justify the reintroduction of its manufacture.

In the light of Dr. Herbert Dow's patent of 1918 on hydrolysis of bromobenzene to phenol and Dr. William J. Hale's work on his patent for direct oxidation of benzene to phenol, these two men sought some way to hydrolyze chlorobenzene without appreciable tar formation. Then too, there was a crying need by the Company of finding some outlet for huge war-surplus stocks of chlorobenzene. This concentrated effort in organic chemistry sprang up simultaneously with the arrival of Dr. Hale in Midland, in the spring of 1919, to establish the Organic Chemical Research Department. To him also goes the credit of establishing a comprehensive chemical library, one of the best in the United States, and now headed by Dr. F. Lowell Taylor. The researches on phenol were highly successful in the hands of Dr. Hale and Dr. Edgar C. Britton—the latter having taken over as director of organic chemical research in 1934, when Dr. Hale retired to research consultant.

This new process for synthetic phenol involved high pressures in a continuous system and yielded most valuable by-products: *o*- and *p*-xenols (phenylphenols). The construction of a plant called for great ingenuity, and to Dr. Putnam, W. H. Williams, and Clarence A. Kohls goes most of the credit for its effectual culmination in the spring of 1923 and 50-tons-per-month production by June. At somewhat lower temperature and pressure the ammonolysis of chlorobenzene was worked out by Dr. Hale, Williams, and J. Walter Britton to yield aniline by simplest possible procedure. Again Dr. Putnam and Williams, as engineers, successfully constructed a continuous process for this chemical, as well as for numerous other compounds growing out of phenol and aniline. Particularly to be mentioned in these organic researches are Dr. Howard S. Nutting, Dr. Shailer L. Bass, Dr. Wesley C. Stoesser, Dr. Ralph P. Perkins, Dr. Gerald H. Coleman, Andrew J. Dietzler, and Walter J. LeFevre. Noteworthy, too, are researches under Dr. John E. Livak, Dr. Halbert C. White, and John C. Vander Weele that have led to commercial production of synthetic amino acids.

In the manufacture of phenol any desired percentage of diphenyloxide of high boiling point and extreme stability is obtainable as coproduct. These properties indicated to Dr. Herbert Dow that here was a valuable high-temperature, low-pressure, heat-transfer medium. Experiments instituted by Dr. Dow fully substantiated the assumption; in fact its eutectic with diphenyl, known as Dowtherm, melts so low as 12° C. This mixture, therefore, constitutes a most serviceable liquid for high-temperature heat transfer within its range, 250° to 385° C.

The Armistice, 1918, saw the Dow Chemical Co. grown to manhood. It was 21 years old, it had a liberal education in chemical manufacturing, acquiring skill and experience, and its assets were some $6,000,000. Its immediate future, however, was not alluring. Wartime markets had vanished and the Company was left with expanded facilities in some lines which appeared to be all out of proportion to the needs of a peaceful world. There appeared to be but two alternatives: retrench or research. To Herbert Dow, the chemist, there was but one answer worth contemplating. He became president and general manager that year, while A. E. Convers moved to the newly created honorary post of chairman of the board, and the research program, which had been growing at a healthy pace, was stepped up briskly. Attention was concentrated on markets, either direct or as chemical intermediates, and toward greater utilization of by-products from existing processes. At the same time, the pressing need for salable organic chemicals resulted in research and marked development in this field. The manufacture of mustard gas, for example, involved production of ethylene; and peacetime outlets were imme-

diately sought through such products as ethylene chlorohydrin and ethylene glycol. Both were brought to market late in 1918, but were virtually without takers although they now enjoy wide demand.

These developments promoted both aliphatic and aromatic organic chemicals, such as ethylene oxide, phenylethyl alcohol, synthetic oil of wintergreen, coumarin, diphenyl, and diphenyloxide. These two lines of research springing from ethylene and benzene came together later as the foundation of Dow's styrene development. By the beginning of the 1920's the plants were again in capacity operation and even looking toward expansion. That decade saw Dow become its own best customer for such basic commodities as phenol, chlorine, caustic soda, and bromine. Once started, the program seemed almost self-nourishing as each new development brought with it possibilities for further development—many useless or impractical to be sure, but always enough good ones continually to extend the horizons.

While this intensive program was pursued internally, the external influences of the Booming Twenties were also having their impact. Phenol became something more than a disinfectant with an unpleasant odor. Combined, strangely enough, with another disinfectant, formaldehyde, it became Bakelite. Demand for the versatile, moldable insulating material swelled the demand on Dow for carbolic acid. Today (1947) over half the synthetic phenol in this country is produced at Midland. A motoring public demanded better roads, and Dow's calcium chloride, which had known only modest use in refrigeration brines, became Dowflake, which because of its hydroscopic nature, is capable of allaying the dust nuisance. The flake product, first of its kind, was introduced in 1919 and its sales curve rose sharply almost from the beginning.

Such cases are exemplary of developments during that bustling decade which ended with Dow Chemical looming large in American industry as a $24,000,000 corporation with sales of $18,000,000. Volumes could be written on the human effort, the trials and errors, the disappointment and elation accompanying such a record of corporate expansion. The United States has become great because of its talent for the collective use of resources. The brains of many men, the hands of many men, and the money of many men joined together to form what we call industry. In this respect the history of the Dow Chemical Co. is the history of its country, and never was this more evident than in that decade. Among the brains behind that period of Dow's progress were names which have become legend within the organization. Helping to put the work of such men to beneficial use were the holders of more than 60,000 shares of new stock issued between 1923-29 which brought over $4,250,000 new capital into the operation and created hundreds of new jobs.

Amid the chaos and gloom of the depression that swept the country after that black day in Oct. 1929 when stock market prices crashed, Dow Chemical Co. suffered a severe personal blow. On the night of Oct. 15, 1930, newsboys hawked an extra edition of the *Midland Republican*: Dr. Herbert H. Dow had passed away. To the community he was the founder of an industry that had brought unprecedented prosperity to its people; its most revered citizen, a democratic, human man who had risen and had not forgotten to help his fellow man up with him. He was not only the leader of the city's only big industry, but also its keenest proponent of civic betterment. To the Company he was all this and more. He was its president and general manager—the dogged genius of chemical and human engineering who had guided it through 33 years. In the face of nation-wide panic his loss could be a corporate as well as a personal tragedy.

Into his father's shoes stepped Willard Henry Dow, just a few months older than the Company itself. He was not unprepared. He had been brought up with

the Company; studied chemical engineering at the University of Michigan, graduating in 1919; spent intervening summers on various plant jobs as might be assigned to any young technical employee; and by 1926 had risen to assistant general manager. But the job was a big one and the timing hardly to his advantage.

Willard Dow met the depression with an onslaught of expansion and new development. As he himself modestly expressed it a few years ago: "While the rest of the world was in very great depression our people continued to be stimulated with the thought that there were new worlds to conquer, that the horizon was ever distant, and that there was an infinite amount of work for all if we could develop markets for a few (new) products." There were minor curtailments, but in Michigan, Midland was referred to as "the town that never knew there was a depression." Dow Chemical went all out for research, and some of its most significant developments are products of that calamitous era. Foremost were the extraction of bromine from the sea and the successful production of Dow's three primary plastic materials—Saran, Ethocel, and Styron—and an ever-expanding series of Dowicides.

Meanwhile Dow's corporate entity grew arms in many directions. Jan. 20, 1930, the Midland Ammonia Co. was formed to utilize waste hydrogen from the electrolytic cells, thereby extending ammonolytic processes at home. Nov. 10, 1932 saw the birth of Dowell, Inc., a wholly owned subsidiary to carry Dow's process for acidizing wells to the petroleum industry. In this lay great promise for increased recovery of petroleum from certain types of wells, while cleaning boilers and such by specially inhibited acids opened still wider horizons. To Dr. John J. Grebe, Dow's physical research director, falls the credit for instituting the researches that sustain this subsidiary.

Dow Chemical Co. and Ethyl Gasoline Corp. (now Ethyl Corp.) on Aug. 4, 1933, set up a 50-50 subsidiary, Ethyl-Dow Chemical Co., for the production of ethylene dibromide from the bromine extracted from the sea at Kure Beach just below Wilmington, N. C. By Mar. 1934 the plant was in commercial production. The extraction of bromine from sea water was little short of sensational when it is considered that there is only one pound of this element in about 15,000 lb. of raw sea water. In the researches here concerned stand out Dr. Grebe, Ivan F. Harlow (now production manager of inorganic products), Sheldon B. Heath, and George W. Hooker; in the launching of the enterprise, Lester J. Richards, Dow's chief engineer, Dr. Barstow, Dr. Albert P. Beutel, now general manager of the Texas Division, Harlan Sherbrook, Carl A. Branson, Grayton F. Dressel, C. Monroe Shigley, Glen Cantwell, Earl R. MacLaughlin, Walter H. Rupprecht, and Norris E. Coalwell. Ethyl-Dow operations are now centered at Freeport, Tex. The basic key to this entire development is regarded by many to be Dr. Grebe's application of the electrometric potentiometer to automatic control of the pH of incoming sea water.

Universal demand for insecticides brought into prominence a class of phenolic compounds carrying varying degrees of halogenation. These are known as Dowicides and exhibit both fungicidal and germicidal properties. Their development and extensive adaptation have been under the direction of Lindley E. Mills, Arthur M. Griswold, Robert B. Reese, and Donald K. Ballman. Highly chlorinated hydrocarbons, as hexachlorocyclohexane and the like, have only lately come into use as insecticides. This field is under study by Dr. Francis N. Alquist. Chlorinated hydrocarbons have long been of foremost importance. The unsymmetrical dichloroethylene (vinylidene chloride), previously not studied, has been copolymerized with small amounts of aliphatic monohalides or similar compounds, to yield Saran, a plastic of outstanding characteristics, especially in its water repel-

lency. First findings were made by John H. Reilly and Ralph Wiley in Dow's physics laboratory.

In 1934 Jones Chemical Co., an iodine plant in Louisiana, jointly developed by Dow and Dr. Coulter W. Jones, a former Dow man, became Io-Dow Chemical Co. These iodine operations were subsequently moved to California and ultimately became wholly Dow Chemical-owned and later a part of the Great Western Division. Prominent in this development were Dr. Jones, Dr. Grebe, Dr. Beutel, Heath, L. J. Richards, Chamberlain, Fred Lusk, George Hooker, Glen Cantwell, Maurel F. Ohman, Harold Hilsinger, Hubert O. Fox, Clifton Hilderly, and many others. May 24, 1935, a controlling interest in the Chemical Division of the Cleveland-Cliffs Iron Co. at Marquette, Mich., transformed it into Cliffs Dow Chemical Co., a subsidiary of Dow, manufacturing hardwood distillation products. Prominent in the Cliffs Dow development were Dr. Putnam, G. F. Dressel, Wm. H. Williams, Dr. Britton, Nelson D. Griswold, and R. Wesley Jenner.

In 1936 Dow opened a magnesium foundry and fabrication plant in Bay City, Mich.; and at Ann Arbor it established a product service laboratory under Walter L. Badger. On Dec. 31, 1938, the Great Western Electro-Chemical Co. of California, formed in 1915, became the Great Western Division of Dow with Russell L. Curtis, general manager; Dr. W. Hirschkind, director of research; C. W. Schedler, plant manager; James F. Smith, sales manager; Albert Johnson, Edward J. Dunlap, Harry Burris, Richard Martyr, and Ray Cornelison. The main products of the Division are chlorinated solvents, xanthates, caustic soda, caustic potash, liquid chlorine, liquid sulfur dioxide, and an important group of agricultural chemicals.

Ethocel, a plastic of most interesting foil and coating possibilities, early came into the triad of Dow plastics which includes its sister compound Methocel, soluble in cold water and insoluble in hot water, and carboxymethylcellulose. All are under intensive study by Dr. W. R. Collings, Dr. Floyd C. Peterson, Dr. M. J. Hunter, T. A. Kauppi, E. P. Samsel, Richard W. Swinehart, Merrill H. Weymouth, Albert T. Maasberg, Arthur E. Young, and others.

The story of Styron rings true. Its antecedent is styrene derived from ethylbenzene. The resulting clear liquid polymerizes under certain conditions into a clear solid plastic material which can be melted and molded into various shapes. Unfortunately the early-made product discolored after a few weeks, acquiring a multitude of minute cracks. It was ultimately determined that most of the difficulty sprang from impurities in the liquid styrene. The solution lay in controlling the styrene production process with precise accuracy. This was by no means a new problem, it having been repeated with product after product since the days of H. H. Dow's first impure and unsalable bromides; but with styrene it proved to be exceptionally vexatious. The persistent work of many men eventually solved it and a high-quality polystyrene plastic was offered in 1937 under the name Styron. Especially notable among the many who worked on the styrene development were Dr. E. C. Britton, Dr. Grebe, J. W. Britton, Dr. Ray H. Boundy, director, Plastics Division, Robert Dreisbach, Lawrence Amos, Leonard C. Chamberlain, C. C. Schwegler, and Ray F. Boyer.

There was another unexpected angle to the styrene story, however, that made the work of these men and their associates of historical importance. The product and the processes they were developing were one day to keep their country, faced with global war, from being impotent for lack of rubber. Styrene and butadiene are the two major materials involved in the manfacture of Buna synthetic rubber. In butadiene research and development Drs. Britton, Grebe, Nutting, Noland Poffenberger, Lee Horsley, and Perkins were the pioneers.

In Dec. 1940 was formed the Goodyear Dow Corp. (owned 50-50 by Goodyear Tire & Rubber Co. and Dow Chemical). In Jan. 1941 this corporation submitted to the Reconstruction Finance Corp. a proposal to contract for a production of 10,000 long tons per year of synthetic rubber of either the Buna S or Buna N type. Dow Chemical was prepared to supply all technical information for the manufacture of styrene and butadiene, and Goodyear that for the copolymerization of the two compounds. However, this proposal was held in abeyance for a year and a half or until the rubber shortage became acute. Though Dow Chemical was the first commercial producer of both styrene and butadiene, it could do no more at this later date (1942) than accept responsibility primarily for production of styrene, the oil companies for the most part taking the responsibility for butadiene, and the rubber people for polymerization. As a result of this trend of developments, the Goodyear Dow Corp. was dissolved and never functioned.

Ultimately Dow's styrene process was used in whole or in part in four of the five government styrene plants built for the rubber program. While the Company's butadiene process, developed during those same years, was not adopted for the rubber program, Dow was able to supply the material for the vital rubber development work in the early days of the war. Styrene and butadiene were but two of the numerous depression-born children of Dow arriving in time for strategic military service.

In 1939 the Texas Division was established at Freeport to extract magnesium from sea water and ultimately to utilize Texas petroleum in the manufacture of organic chemicals. The first ingot of magnesium to be taken from the sea was poured on Jan. 21, 1941, an historic date in science. The building of the Texas Division involved scores of Dow men, some of whom moved to the site while others almost commuted between Midland and Freeport. Directing from the start was Dr. A. P. Beutel, assisted by Calvin A. Campbell, J. P. Bryan, George M. McGranahan, and many others, most prominent of whom were Dr. Barstow, L. J. Richards, S. B. Heath, R. M. Hunter, Louis E. Ward, George M. Greene, Felix Glaza, Ivan Oden, Harlan Sherbrook, Oliver Beutel, Kendall May, Lewis F. Warsing, Ralph Schneider, William P. Schambra, John R. Stein, and Leo D. Richards, supplemented by the entire Dow Engineering Department at Midland. Later Nelson D. Griswold, C. Monroe Shigley, Henry Roebke, David Landsborough, Walter Roush, and Dr. Edward R. Wright came into the operating picture.

Thus during the dismal thirties did Dow's corporate structure expand at the rate of a new division or subsidiary per year. Its production was hard pressed to keep up with its research, and it entered the forties with a product list in excess of 500 items and assets in the neighborhood of $48,000,000. It was well prepared to help fight and win the most monstrous war in history—World War II—during which it designed, built, and operated styrene plants for the Government at Velasco, Tex., and Gardena, Calif., and at Sarnia, Canada, for the Canadian Government. Likewise Dow built and operated for the Government, magnesium plants at Freeport and Velasco, Tex., and Ludington and Marysville, Mich., in addition to expanding its own facilities in Freeport and at the Midland plant. So well was Dow prepared that it produced more than 91% of all the magnesium turned out in the country during the critical year of 1942. At the same time it expanded its fabrication and foundry facilities in Bay City for the production of vital aircraft parts and bore most of the burden of supplying know-how to other fabrication shops.

Dow's plastic products served many specialized uses and its technical men worked virtually night and day in collaboration with military services. Saran monofilaments, woven into insect screening, went to military bases in humid Pacific

regions where metal rusted and cloth rotted. Styron, in almost microscopic fibers known as Polyfibre, was molded into the first successful radar housings for aircraft, the key to the licking of the "wolf pack" menace in the Atlantic. A special form of Ethocel became a part of the famous "proximity shell fuse" that, after years in development, was given major credit in winning the Battle of the Bulge. Dow developed Saran film and Stripcoat to protect machine guns and precision parts and instruments from corrosion in shipment. Its bread-and-butter items all contributed their bit and there scarcely was a pound of anything produced that was not shipped for war or semiwar purposes.

Of especial war importance, too, was the work of Dow Chemical and Corning Glass in the entirely new and revolutionary field of silicone chemistry. This led to the formation, Feb. 17, 1943, of Dow Corning Corp. and erection of a commercial plant at Midland. Prime movers in this enterprise included Dr. E. C. Britton, Dr. Collings, Dr. Bass, Dr. Melvin J. Hunter, Olin D. Blessing, Toivo A. Kauppi, and Howard N. Fenn. Initial operations were concentrated largely upon a particular compound, now designated DC-4, used to seal the ignition systems of high-altitude military aircraft. The effect was to give American aircraft a distinct working altitude advantage. This and other silicone products are now finding diverse specialized uses in industry, and Dow Corning as yet is the only commercial producer.

Dow was fortunate in having few immediate, major reconversion problems, but it was apparent that World War II had done little to improve its position. On the contrary, the conflict had forced postponement or abandonment of many promising research and market development programs, and in some lines established competition where none had previously existed, refuting the all-too-widespread notion that industries grow fat on such global tragedies. The normal growth and market development of such products as Saran, styrene, Polyfibre, butadiene, Dowicides, and intermediate chemicals of many kinds were stopped as they were channeled to the needs of the Army and Navy and other strategic services. The hard-won position of synthetic solvents in the dry-cleaning industry was completely wiped out, necessitating a "start from scratch" at the end of hostilities. Even in magnesium, which seemed to gain impetus from the war, it would be difficult to prove a gain, for its use was expanding rapidly in the years just prior to the war, as evidenced by Dow's move greatly to expand production as early as 1939. Styrene is an example of a Dow war casualty. Because of the tremendous need for synthetic rubber, it was necessary for the Company to turn many of its developments over to industry at large and styrene came out of the war with an overcapacity of two to three times what the country could consume. Where Dow had been the only prewar producer, its war legacy was two styrene competitors using all or parts of Dow's own process.

From a cost standpoint, it is estimated that revamping operations to peace will have cost Dow about $20,000,000. The war was distinctly not a profitable piece of business. Despite this, the Company's growth was maintained and the pattern unfolds optimistically. Gross sales for the fiscal year 1945-46 were $101,800,000, only 20% below the wartime peak of $124,570,000. In 1946-47 they have risen above that all-time high to about $130,000,000. Another decade of expansion is already well begun. Dow Chemical of Canada, Ltd., a subsidiary formed June 5, 1942, to operate the styrene plant at Sarnia for the Canadian Government, is now revamped and, under management of N. Russell Crawford, ready to convert a portion of that styrene into the plastic Styron, also for the production of ethylene glycol. On Feb. 7, 1947, Dow purchased from the War Assets Administration the huge styrene plant it built and operated at Velasco and on Dec. 31, 1947, another government-owned plant at Ludington, Mich., for production of calcium and mag-

nesium chlorides. In addition, many millions have been authorized for the extension of facilities in many lines of production and in virtually all of Dow's present locations.

On July 23, 1947, the Dow Chemical Co. changed its state of incorporation from Michigan to Delaware to provide itself with a perpetual charter and otherwise facilitate a streamlining of its operations. In general, the scope of manufacture, outside of the simple brine components, has been kept closely within natural limitations, namely: caustic soda and halogens. These two products are the radial lines of an angle enclosing the Dow field of inorganic and organic activity. They take their origin at the vertex in common salt. In the march of progress these lines necessarily diverge and enclose an ever broadening sector while the network of interlocking processes within builds newer and better support for the structure as a whole.

The present (1948) officers of the Company are: Willard H. Dow, president; Earl W. Bennett, vice-president and treasurer; Leland I. Doan, vice-president and secretary; Edwin O. Barstow, Charles J. Strosacker, and Mark E. Putnam, vice-presidents; John S. Crider, assistant treasurer. All are directors, together with the following: Alden B. Dow, William R. Veazey, A. P. Beutel, Calvin A. Campbell, Russell L. Curtis, Carl A. Gerstacker, and Nelson D. Griswold.

DRACKETT COMPANY, manufacturers of Drāno and Windex and large-scale processors of soybeans, was organized in 1910 as P. W. Drackett & Son. In the early days this partnership distributed bulk chemicals to industrial users throughout the South and Middle West, as selling agents for chemical manufacturers. In 1915 the Company was incorporated, and subsequently manufacturing operations were begun, the principal products being Epsom salt and lye. By 1922 the sale of bulk chemicals had been largely discontinued. That year the name was changed to the Drackett Chemical Co.; in 1933, to the Drackett Co.

When the Company was incorporated, H. R. Drackett, eldest son of P. W. Drackett, was elected president, which office he held until his death in Mar. 1948. He was succeeded by his eldest son, Roger Drackett. From 1915-44 the stock was closely held, two-thirds of it by four men. In 1944 the Company was refinanced and stock offered for public sale.

Officers and directors as of 1948 are: Roger Drackett, president and director; James J. Heekin, vice-president and director; Arthur H. Boylan, vice-president of marketing research and advertising; Albert E. Heekin, treasurer and director; K. H. Jones, vice-president in charge of finance and secretary; Daniel M. Heekin and David G. De Vore, Sr., directors.

Drāno, the original drain cleaner and opener, was launched in 1922 and grew rapidly throughout the United States and Canada, and in many foreign countries. In 1933 Windex was introduced and today its volume is greatest of all branded liquid window cleaners. Believing that one of the greatest assets a company can have is products that are known, Drackett has invested heavily in Drāno and Windex advertising, expenditures averaging $500,000 annually for many years. Drāno and Windex sales are served by Drackett Products Co., a subsidiary, through representatives in Boston, New York, Philadelphia, Atlanta, Pittsburgh, Detroit, Chicago, Birmingham, Cincinnati, St. Louis, Dallas, Minneapolis, Los Angeles, and Seattle.

After considerable research, the Company began processing soybeans in a small way in 1937. Two years later the first structures on the new 75-acre Sharon plant were built, and processing became full-scale. Until 1945 extraction of soybean oil and production of soybean meal were the principal commercial operations. In

recent years new plants have been put into operation at Sharon for the manufacture of industrial proteins, textile fiber, and plastic molding compounds. Drackett's protein is used in paper coatings, in the manufacture of buttons, latex compounds, and adhesive bases. Drackett protein textile fiber blended with other fibers is being used by various textile mills to create new yarns and fabrics. Production is still in the experimental stage (1948). Drackett plastic molding compound produces molded parts with new and desirable characteristics.

All Drackett products are results of the Company's own laboratory research. To insure continued growth, a considerable portion of the Company's resources, both in men and money, is being put against future products. Many of these will come from the soybean, others will be household products.

E. I. DU PONT DE NEMOURS AND COMPANY was established when a series of crises was shaking Europe. Out of the French Revolution had risen Napoleon to become dictator of most of Europe. England was fighting for its life. The United States, young and weak, was trying desperately to keep Europe's troubles from its shores. America badly needed gunpowder. The only good powder was imported, chiefly from England, and it was almost as important as clothing and food. It was needed on the frontier. It was required in hunting, an essential activity. It was in growing demand as a blasting agent for land clearing, mining, and engineering.

Among French refugees then in the United States was Eleuthère Irénée du Pont de Nemours. He had been trained in gunpowder making by Antoine Lavoisier, great French chemist, as the first step in what was to have been his general chemical education. But Lavoisier had been beheaded and du Pont's father imprisoned. Later the du Pont family fled France, landing at Newport, R. I., on Jan. 1, 1800. Irénée du Pont, then 28 years, had a wife and three children to support. He was without capital, but he did have friends. One of them was Thomas Jefferson, who encouraged young du Pont to raise funds and erect a gunpowder mill wherein would be introduced the newest French technique.

Thus, in 1802, E. I. du Pont de Nemours & Co. was founded on the banks of historic Brandywine Creek, near Wilmington, Del. Difficulties beset the venture from the outset. Only part of the capital promised was ever paid up. Two years passed before any powder was ready for sale. Then customers insisted on long-term credits and du Pont was soon heavily in debt. Explosions destroyed part of the mills. Du Pont's American partner deserted and started a rival mill near by that enticed away many of du Pont's best workmen. However, when the War of 1812 jeopardized the country, du Pont gunpowder was ready to defend it. Orders for 50,000 lb., then 200,000 lb., then 500,000 lb. were placed with the du Pont mills, which had to be expanded. Du Pont went more heavily into debt. The Government itself was financially helpless, a result of the British blockade of our Atlantic Coast.

Peace found du Pont with $125,000 tied up in raw materials and finished powder, debts exceeding $100,000, and $10,000 in cash.

On the war he wrote: "Should its final result produce no other good than to secure the establishment of home manufacturers, so that we could make our own goods for our own use, it would repay the nation tenfold for every expense and loss. . . . Manufacturing is a true creation of wealth. It is taking cotton which costs 20¢ per pound and making it *worth* several dollars. It is taking wool at $1 and selling it again at $6 or $7 when it has received its metamorphose from our industry. Let us reap then the full advantage that this war may produce. Let us secure forever the establishment of American manufacture. . . ."

This doctrine that the United States should secure its economic as well as political independence was to guide du Pont policies to the present day. It was the incentive to Eleuthère Irénée du Pont de Nemours, throughout the 32 years until his death, to place a firm foundation under the American explosives industry. His objective was not alone to make American gunpowder always ready for American guns in wartime. Even more determinedly he wanted American explosives to serve the vastly greater needs of the country's builders in peacetime. In achieving these ends he performed a notable feat. Until his time no American powder mill had been able long to survive the hazards of the business and foreign competition. Du Pont's mills survived both.

By dividing his mills into small units and spacing them well apart—a new practice in the United States—he limited the devastation of accidental explosions. He made a fetish of safety for the worker, one which his successors were to follow with almost religious fervor. The term workmen's compensation was yet to be coined, the labor movement to be born, but du Pont made it a fixed rule that men injured in the Company's work were to be given adequate care, that in the event of a workman's accidental death his family would be cared for by the firm. It was a family business. Du Pont's home overlooked the mills. There his sons went to work, to return at night as powder-smeared as any day-laborer. The yards along the Brandywine were not open to visitors. Workmen and their families constituted a closed community because black powder and strangers not constantly respectful of its dangers did not mix safely.

On Oct. 31, 1834, Eleuthère Irénée du Pont de Nemours died of a ruptured heart in a hotel room in Philadelphia. To that city, by horseback as a rule, he went almost weekly for more than three decades to meet his notes with his banker-creditors. He died still in debt, but that year the mills he had founded manufactured more than 1,000,000 lb. of black powder. His name and work lived.

Probably about 175 workmen were in the du Pont employ in 1834. By covered wagon and coastwise ship the powder went south to New Orleans, north to Maine, and westward to the remotest forts and settlements. It moved in the first boats through the Erie Canal, helped clear the way for the first railroads, blasted out stumps for new farmland. The business contributed substantially in giving the country an American powder fully equal in quality to any made in Europe, at reduced prices. Good imported powder sold at 40¢ a lb. before the War of 1812: du Pont powders, at 16-20¢ when the second generation took over.

Third of the founder's seven children and eldest of his three sons, Alfred Victor du Pont was 36 when his father died. He knew the shops and mills, but not the front office, so Alfred was grateful when his brother-in-law, Antoine Bidermann, agreed to become temporary head of the firm. Bidermann was a veteran of 20 years in the sales and business sides of powder making. So ably did he manage, that in the spring of 1837 he paid off the last dollar owed the original subscribers to the firm's capital. They had long felt that too much was being plowed back, too little paid out in profits.

Apr. 1, 1837, Bidermann retired, leaving Alfred and his brothers, Henry and Alexis Irénée, and their four sisters, Victorine, Evelina, Eleuthera, and Sophie Madeleine, sole owners of the enterprise. The brothers and sisters met in the Company's office and drew up a partnership agreement that was to endure for 62 years, one of the most unusual in American industrial history. The name of E. I. du Pont de Nemours & Co. was retained, but there were to be no officers; the three brothers, as active managers, were to assume no titles. Profits and losses were to be shared alike. Everything belonging to the partnership was to be jointly owned and apportioned according to each of the partner's needs, including homes and

farms, farm produce, the horses and carriages. No salaries were to be paid, but each partner was to draw as needed from the firm's cash. Withdrawals were to be deducted later from his or her share of the profits. As the eldest son, Alfred was to act and speak for all seven, sign all letters, draw all checks. In disputes his word was to be final. In accord with this agreement until almost 1900, du Pont women sat with du Pont men in all important business meetings.

A little more than a year after the partnership took charge, the country plunged into one of its worst business depressions. Business survival was a struggle for almost seven years. Competition showed no quarter. Blasting powder often sold at less than the cost of delivering it.

The Mexican War in 1846 created the usual emergency demanding hurried expansion of powder production. Inexperienced men added to the force and work often pushed by lamplight multiplied the hazards. In the rush somebody was careless, a spark ignited powder in a press: from the debris of the explosion-wracked mills were taken 18 dead.

Alfred Victor du Pont retired in 1850, a semi-invalid, and turned over his office to his younger brother, Henry du Pont. Vigorous, robust, and 38, this American-born son of the founder was a West Point graduate and former Army officer. Known widely as General du Pont, by virtue of service as Adjutant General of Delaware and later as Major-General commanding the State's Union volunteers, for almost 40 years—until his death in 1889—he was to dominate the du Pont interests more completely than any other one man before or since. Earlier du Ponts had been concerned largely with improving manufacture. General du Pont inaugurated better methods of management and moved boldly to expand sales. During the gold rush of 1848, he chartered speedy clipper ships that could deliver gun and blasting powders from Wilmington to San Francisco in three months, a record schedule. In the booming West Coast city he set up a sales agency. Overland, du Pont powder followed the Santa Fe Trail. Metallic powder kegs were introduced, replacing the ancient wooden kegs.

In 1857 the invention of "B" blasting powder, or soda powder, was announced. Its formula was 72 parts refined Chilean sodium nitrate, 12 parts sulfur, 16 parts charcoal. The economic import of the invention was tremendous, for heretofore black powder had been made exclusively with potassium nitrate, of which India had been the world's chief supplier for more than three centuries. The great nitrate deposits of South America now became usable for the first time. Inventor of the soda powder was Lammot du Pont, second son of Alfred Victor du Pont, who had died in 1856. So large became the demand for soda powder in coal mining that the firm bought outright the powder mill of Parrish, Silver & Co. in Luzerne Co., Pa., rebuilt it, soon turning out there 36,000 kegs of soda powder yearly. That capacity was doubled in a year or two, then redoubled.

The Civil War brought unprecedented demands, not only for powder but also for new techniques in its military uses. Metallic cartridges, breech-loading, magazine rifles, and machine guns were under feverish experiment. A new method of casting cannon, invented by Capt. Thomas J. Rodman in 1847, made possible artillery having bores of 14, 15, and 20 inches. With these actual or pending changes in weapons, gunpowder remained the same. It was yet to be adapted to rapid-fire arms and big-calibre ordnance. The powder technician held the key to the situation. Conspicuous in that role was Lammot du Pont, who alone among Northern powder makers was familiar with the newest European practices and with Rodman's work. Working closely with Rodman, he probably contributed more to the effective use of ordnance by the federal forces than any other powder maker.

It is estimated that the du Pont mills furnished 3,500,000-4,000,000 lb. of military

powders to the Union during the war, exceeding probably by 1,000,000 lb. the output of the Confederacy's one large powder plant at Augusta. Despite the 117% rise in the price of all commodities in the North in less than five years, du Pont powder sold to the Government never exceeded 33½¢ a lb., and that only in the closing months of the war. The peak was but 8½¢ higher than the price of first-grade gunpowder in 1800.

The war's aftermath in the explosives industry was chaos. While du Pont and other large producers had been working almost exclusively for the Government, numerous small mills had sprung up to supply the neglected commercial market. They were built close to mines and had practically no shipping costs. Their flimsy buildings tied up little capital. Huge surplus government powder stocks were dumped on the market, further disorganizing the industry and bringing in droves of speculators. In an attempt to bring order, the larger producers, led by General du Pont, formed the Gunpowder Trade Association of the U. S. The Association set minimum prices for the country by districts, fixed penalties for price violations by members, and pooled resources against nonmembers who broke the industry's code of fair practices. This self-inaugurated policing of the industry proved effective until the panic of 1873, when many of the larger producers encountered serious financial troubles. General du Pont's answer was again direct action. He bought outright some of the faltering companies and acquired stock control of others, preventing bankruptcies.

In 1880 du Pont's one large rival was the Laflin & Rand Powder Co. of Esopus, N. Y. At about this time a prominent engineer applied to General du Pont for a job. The General wrote him: "We build our own machinery, draw our own plans, make our own patterns, and have never employed anyone to design or construct our mills or machinery, dams or races, roads or anything else; being our own engineers and superintendents of all work done at the mills." "We" were the du Ponts in person, and General du Pont might have added that he, personally, replied to all the firm's correspondence in his own hand. With a long-outmoded goose quill, he wrote an average of 6,000 letters a year, mostly at night. The typewriter had been invented ten years before he tolerated one of the "noisy contraptions" in the firm's offices.

Dynamite, invented by Nobel in 1866, at first aroused General du Pont's unqualified hostility. He saw it as a threat to the black powder industry. However, Lammot du Pont became one of dynamite's strongest advocates, and on his continued insistence the firm joined with Laflin & Rand, in 1880, in founding the Repauno Chemical Co. for the exclusive manufacture of dynamite at a plant in New Jersey. An almost limitless new field in explosives was opened. Huge developments in railroad building, in steel, in cement manufacture, and in countless operations involving the blasting of rock were vastly accelerated by dynamite, the new high explosive. Repauno was hardly well under way before it had to be expanded. The trade name given the dynamite was Atlas. Not long after, the Cleveland plant making Hercules dynamite for the California Powder Co., was purchased outright by Repauno and incorporated as the Hercules Powder Co. Thus two names became identified with du Pont that were to become famous as the names of two great chemical companies.

Lammot du Pont resigned from the family firm to devote his entire time to Repauno. He hoped to create a plant so thoroughly mechanized that workmen could be kept outside all dangerous areas. Mixing of ingredients was still done by hand with rakes and shovels. With the help of William du Pont, he developed a power-driven wheel mixer, which, with minor changes, is still in general use. He made other contributions to safer practices, only to become a victim himself. He

was killed at the Repauno plant in 1884, in a vain attempt to head off an explosion in the nitrating house. General du Pont carried on. In 1888, at Mooar, near Keokuk, Ia., he built the world's largest black powder mill. Meanwhile, by further careful investments in other companies, he strengthened the du Pont interests in dynamite until the Company also assumed leadership here. He died Aug. 8, 1889, aged 77, in the house on the Brandywine where he was born.

Successor was Eugene du Pont, grandson of the firm's founder, who had studied chemistry at the University of Pennsylvania and gained practical experience in the Brandywine mills. He was 49, reserved and quiet, nonetheless he moved vigorously to modernize the business. A new office building was erected to replace the little four-room structure that had served more than 50 years. A telephone line was installed and other reforms instituted. For the first time the firm used printed letterheads. Foreseeing the explosives industry's future in dynamite, Eugene gave heavier emphasis to the Repauno Co. In charge there he placed J. Amory Haskell, a young engineer with a notable record in coal mining, assisted by Hamilton M. Barksdale, another young engineer. These two men, neither of them chemists, were notably responsible during the next two decades for replacing rule-of-thumb methods in explosives manufacture with applied chemistry. Largely under Haskell, the Eastern Dynamite Co. was formed as a stockholding company for investments in producing companies. In addition to holding the presidency of Repauno, Haskell became president of Laflin & Rand. The two old rivals in black powder were now in open alliance.

A sign of the dynamite industry's rapid technical progress at this stage was the fact that in less than ten years after being completely modernized, the Hercules dynamite plant at Cleveland was condemned as obsolete and scrapped. Within the decade American dynamite production was more than quadrupled.

At the old black powder mills on the Brandywine, Eugene du Pont in 1890 set up a laboratory under Francis Gurney du Pont, a veteran of the business, to develop a smokeless powder. The research assistant was Pierre Samuel du Pont, eldest son of Lammot, fresh from M.I.T. and not yet old enough to vote. Next spring a more elaborate laboratory for smokeless powder research was built at Carney's Point, N. J., across the Delaware River from Wilmington. Also, at the request of the Navy, a guncotton plant was built there. In 1894 the first du Pont smokeless powder was put on the market, in time for the rabbit-hunting season.

As the century ended, so did the partnership of du Ponts formed in 1837. The load on the senior partner was too heavy, so on Oct. 23, 1899, E. I. du Pont de Nemours & Co. was incorporated in Delaware. Actually, the change was in form only, for president Eugene du Pont continued to carry the senior's burden; only the elder du Ponts sat with him in conference. That year young Pierre Samuel du Pont left to join an adventurous cousin, Thomas Coleman du Pont, in other activities in the Midwest.

In Jan. 1902, Eugene was stricken with pneumonia and died within a week. The failure of the du Pont elders to encourage youth to share in the management now became painfully apparent. At a meeting of the directors to elect a new president, the short list of available du Ponts yielded nobody suitable because of increasing age, ill health, or other reasons. A resolution was offered that negotiations be opened for sale of the Company to Laflin & Rand. One of the younger du Ponts suggested that the resolution should be made to read, "sale to the highest bidder." Thus amended, it was unanimously passed. To the du Pont elders' astonishment, they had an immediate bid from Alfred Irénée du Pont, author of the amendment. Alfred was 38, a stockholder and director, and thoroughly schooled in black powder manufacture, but his elders considered him too specialized in experience to head the

Company. He asked for a week in which to prepare an offer to purchase at as high a price as anybody else would pay, and insisted that this opportunity to buy was his birthright. Not without misgivings the surprised group acceded to his request.

Two days later, Alfred met in Wilmington with two first cousins, Thomas Coleman du Pont and Pierre Samuel du Pont, summoned hurriedly from Ohio by long-distance telephone. Coleman, an engineer, was almost of the same age as Alfred. In a diversity of business ventures in the Midwest and South he had displayed marked ability as an organizer. Pierre, the chemist, was now 32. During his absence of three years from Wilmington, working with Coleman, he had proved himself an able administrator with an unusual knowledge of finance. Both cousins were eager to join in Alfred's daring plan to buy the business of their forebears. However, the best offer that the three could hope to make in the week allowed them was a small payment in cash and their promissory notes for the balance, secured by the stock of a new company to be formed by them. It was their turn to be surprised. Their offer was accepted by the elder du Ponts. Moreover, cash payment was waived in return for one-fourth stock interest in the proposed new company. The price was fixed most reasonably at $12,000,000.

Pierre wrote his younger brother, Irénée du Pont: "We have not the slightest idea what we are buying, but we are probably not at a disadvantage, as I think the old company also has a very slim idea of the property they possess."

On Mar. 1, 1902, the three cousins assumed full management. Coleman became president; Alfred, vice-president; and Pierre, treasurer of E. I. du Pont de Nemours & Co., which owned outright and operated five plants, at Sycamore, Tenn., Mooar, Ia., Wapwallopen, Pa., Carney's Point, N. J., and the parent plant on Brandywine Creek. These plants manufactured and sold 36% of the black blasting powder used in the United States, and through the Carney's Point plant, a major share of the newly developed smokeless powder and guncotton then being used in small quantities by the Army and Navy. However, the five properties represented only about 40% of the total assets: 60% was in outside investments.

The Hazard Powder Co. was owned outright, but more than two-thirds of its assets were also represented by outside investments. Together, the du Pont and Hazard stockholdings comprised minority interests in 16 fairly large companies and majority interests in two, exclusive of their own concerns. Furthermore, in 13 of these companies the Laflin & Rand Powder Co. was also a substantial minority stockholder. When the tangled skeins of du Pont, Hazard, and Laflin & Rand holdings were finally unraveled, it developed that the three companies jointly controlled 15 out of 22 important explosives manufacturers other than themselves, and had large minority holdings in the remainder. In addition, through these 22 larger companies or by direct investment, the three had stockholdings in upwards of 50 smaller powder concerns.

Poring over these facts, the three cousins were less and less satisfied with what appeared to them to be a dangerous element in 60% of the du Pont Co.'s assets: the necessity of maintaining cooperation with Laflin & Rand. Two courses were open: first, to dispose of all du Pont-Hazard outside holdings, an action that might easily disorganize the industry and jeopardize all they possessed; or, second, to safeguard their present holdings by buying enough additional stocks of the various companies to give du Pont-Hazard a majority interest in each. Coleman du Pont chose the second course; in Oct. 1902, he bought Laflin & Rand for $4,000,000.

Reasons other than financial security prompted Coleman's bold stroke. The many companies, each with its own plants, sales organizations, and other facilities, resulted in much overlapping effort and waste. Secondly, recent court decisions had broadened the scope of the Sherman Anti-Trust Act, casting doubt over the legality

of the Gunpowder Trade Association and certain of its agreements at home and abroad. Thirdly, Pierre du Pont was keenly conscious that most of the new developments in explosives—nitroglycerin, nitrocellulose, smokeless powder, dynamite—had originated in Europe. He foresaw the need for an unprecedented expansion of American chemical research. As a result, du Pont's purchase of Laflin & Rand brought about the greatest overhauling that the American explosives industry had undergone throughout its history. The Gunpowder Trade Association was dissolved; its agreements canceled. Company after company was dissolved and their properties vested in the du Pont Co. through exchanges of stocks. Badly situated plants were dismantled; duplicating sales offices were consolidated. Coleman moved headquarters from the Brandywine into the city of Wilmington.

At Repauno, in 1902, the Eastern Laboratory was established to specialize in explosives research. It was destined to make notable contributions to industrial blasting, including developments in low-freezing dynamites and "permissible" explosives. In 1903 a second research laboratory called the Experimental Station was established on Brandywine Creek not far from the Company's founding site. Fields related to explosives were here explored, particularly cellulose.

In 1905 the International Smokeless Powder & Chemical Co. was bought. At Parlin, N. J., this company produced not only gunpowder but nitrocellulose solutions and solvents, and lacquers for coating polished brass. Its purchase was a step definitely beyond explosives toward the new chemically related fields that were beckoning. That same year a Technical Section was organized to provide trained men to assist customers in the use of du Pont explosives. The idea was to be adopted generally through the du Pont Co. as its lines of products multiplied and rule-of-thumb gave way to science. By 1906 the Company was spending $300,000 annually for chemical research.

Meanwhile, management was centralized under an executive committee (formed in 1903) to which the ablest executives were admitted without respect to family. A bonus plan was inaugurated and a fund was established in 1904 for pensioning incapacitated employees of 15 or more years' service.

Du Pont was now in a broadening field of industrial action. In the explosives industry, its leadership was unchallenged to the extent that in 1907 the U. S. Department of Justice filed suit against the Company and its officers, its undissolved subsidiaries, and the former members of the Gunpowder Trade Association for alleged violation of the Sherman Anti-Trust Act. In 1911, after four years of litigation, into which every person of prominence in the industry was drawn, a federal court found against the defendants. The evidence revealed that 64 corporations had been acquired and dissolved in building the new du Pont Co.; 69 others were in process of dissolution when the suit interrupted. The thousands of stockholders of these companies were well satisfied with what had happened—their du Pont stock was paying good dividends—a satisfaction without precedent in antitrust suits.

The court, frankly admitting that it would be impossible to restore conditions in the industry to what they had been, issued an interlocutory decree directing the Government and Company jointly to work out a reorganization, subject to the court's approval. At once, both the Army and the Navy protested that any division of the military smokeless powder business of the du Pont Co. would be contrary to the nation's best interests. They held that government-owned smokeless powder plants in operation provided ample control over du Pont military powder prices, and that it was to the public advantage to have the long association continued.

It required upwards of a year to work out a court-approved plan of reorganization. Effective Dec. 15, 1912, the du Pont business in industrial explosives and

sporting powders was divided among three companies—du Pont, and two new independent corporations, the Hercules Powder Co. and the Atlas Powder Co., named after the dynamite brand names assigned them. Laflin & Rand, the Eastern Dynamite Co., the International Smokeless Powder & Chemical Co., and the numerous smaller du Pont subsidiaries were dissolved. As the du Pont assignment under this dissolution included the Repauno, Carney's Point, Mooar, and the Brandywine mills, du Pont continued to be the largest producer of explosives in the country; it remained the only private producer of military smokeless powder.

Then came the First World War and a demand for explosives such as the world had never before even imagined. Du Pont was thinking of anything but war. Purchase of the Fabrikoid Co., Newburgh, N. Y., in 1910, had taken the Company another major step beyond explosives. A Chemical Department had been inaugurated in 1911 to facilitate administration of the growing du Pont research effort aimed at new products. However, by the autumn of 1914, an early and complete German victory was so threatening that only prompt American industrial assistance could possibly stem the rising Teutonic tide. The Allies had prepared for a war in the open, emphasizing light field guns and shrapnel in their armaments. The turn to trench warfare suddenly rendered much of this armament totally ineffective. Heavy artillery and high explosives were needed to demolish trench systems, and it was with these weapons, plus machine guns, that the Germans were best equipped.

In desperate necessity, France, Britain, and Russia turned to American industry. Orders for smokeless powder and high explosives by the millions of pounds poured in on the du Pont Co. When the Allies succeeded in weathering the first great storm, the volume of their demands was on a steadily ascending scale. Lord Moulton, Director-General of British Explosives Supplies, said in 1916 that the British and French Armies could not have held out during 1915 had it not been for the efforts of three American concerns—J. P. Morgan & Co., the Bethlehem Steel Corp., and E. I. du Pont de Nemours & Co. "The du Pont Company is entitled to the credit for saving the British Army," said General Hedlam, chief of the British Munitions Board.

In terms of earlier wars, the figures for explosives production became astronomical. From a starting capacity of 8,400,000 lb. a year in Oct. 1914, du Pont smokeless powder plants attained 357,000,000 lb. a year before the United States entered the war in Apr. 1917. Twelve months later the capacities of du Pont-operated plants reached 455,000,000 lb. Production of trinitrotoluene (TNT) increased tenfold. In four years of war du Pont supplied the Allied Forces with 1,500,000,000 lb. of military explosives. Du Pont-made powders for propelling shells amounted to 40% of the total consumed. In addition, the Company supplied American industry with one-half of its total requirements for dynamite and black blasting powder, and discharged other commitments to the Government ranging from demolition outfits for field troops to unbreakable eyepieces for gas masks.

To accomplish this work, the Company employed at the peak more than 100,000 persons. It built not only war plants but housing and other community facilities for 65,000 people. It spent $3,360,000 on experimental work, research, and chemical control. Not a single lot of du Pont-made smokeless powder was delivered behind scheduled time, not one pound was rejected as unsatisfactory. When the conflict ended, du Pont prices for explosives were 6-20% less than they were in 1913, although raw materials were costing 132% more, and the 1913 prices for military powder were those fixed as fair by Congressional action, on the heels of the sensationally publicized anti-trust suit.

Through these trying years, the Company's leadership fell on Pierre du Pont.

Because of ill health, Coleman du Pont resigned the presidency in 1915 and Pierre became his successor. No du Pont before him had been asked to carry so great a load, though no other du Pont had the support of so able a general management.

"I am firmly of the opinion," Pierre wrote to the board of directors in Apr. 1919, "that we have now reached another turning point in the conduct of the affairs of E. I. du Pont de Nemours & Co. Therefore, it would be wise to place the responsibility for further development and management of the business on the next line of men." On his recommendation, his brother, Irénée du Pont, was elected president on May 1, 1919. Pierre became chairman of the board.

The du Pont program for broadening its chemical interests was given new purpose by the war. There was a general awakening to the need of a strong, wholly American chemical industry capable of maintaining independence of Europe. The existing industry, made up of hundreds of relatively small units, was in no position to meet the competition or keep up with the advances of the huge foreign combines. Chemical development demanded wide diversification of products, the risk of large sums on research, and far-visioned central direction. Both in the Government and the nation at large a keen awareness was growing that we needed not one but a number of strong chemical organizations to give backbone to our widely scattered chemical industry. Du Pont was among the first of several American groups to take action toward meeting this need.

New capital of $60,000,000 was authorized in 1915. That year the Arlington Co. was acquired, aggressive manufacturers of pyroxylin plastics, lacquers, and enamels. The Fairfield Rubber Co., makers of rubber-coated fabrics, was purchased in 1916. One of the nation's oldest manufacturers of paints, varnishes, and heavy chemicals—Harrison Bros. & Co.—was bought in 1917. Between 1925-33, nine important companies, each in a different field, were purchased: 1925—Viscoloid Co., plastic combs, umbrella handles, toys, and other plastic articles; 1926—National Ammonia Co.; 1928—Grasselli Chemical Co., acids and heavy chemicals; 1929—Capes-Viscose, Inc., cellulose bottle caps and bands; 1929—Krebs Pigment & Chemical Co., lithopone; 1930—Roessler & Hasslacher Chemical Co., electrochemicals, ceramic colors, sodium, peroxides, insecticides, etc.; 1931—Commercial Pigments Corp., titanium pigments; Newport Co., dyes and synthetic organic chemicals; 1933—Remington Arms Co. (majority control only), sporting arms and ammunition. Acquisition of these companies—all well established in certain lines of manufacture—was part of the diversification policy which was initiated during the administration of Pierre du Pont.

More than $400,000,000 was spent between 1920-39 on the development and large-scale manufacture of new chemical materials and products. New manufacturing projects begun included: 1917—dyestuffs and other organic chemicals; 1920—viscose rayon yarn; 1923—cellophane cellulose film; 1924—synthetic ammonia and photographic film; 1925—industrial alcohol; 1928—seed disinfectants and acetate rayon yarns. The fact that a majority of du Pont's most important original research developments, including neoprene synthetic rubber and nylon, came after 1928, is significant of the years of preliminary scientific effort that they demanded. They represented 40% of the Company's total sales volume 10 years later.

The over-all evidence of change effected chiefly during the 1920's and 1930's is shown by the Company's reports to stockholders. In 1913 it employed 6,222 persons, had about $75,000,000 in assets, and derived about 97% of its income from explosives. At the end of 1939 du Pont employed 54,800, owned assets in excess of $850,000,000, and more than 90% of its income was from sources other than explosives.

Four basic policies guided this growth: (1) The industrial fields entered were relatively new, or else old but with prospects of improvement because of the very lack of improvement marking their recent histories. (2) Du Pont-trained men invariably accompanied the investment of du Pont dollars, by additions to the personnel of each business acquired. (3) Scientific research to improve both processes and products, and above all to create new and better products, was pushed on a scale ascending with sales. (4) Investment of capital was consistently followed by the venture of more capital aimed at improvement.

Let us watch these policies in action, first behind the scenes during World War I, and then during the two decades preceding World War II—until 1926 under the presidency of Irénée du Pont, and from 1926-40 under his younger brother, Lammot.

The dye shortage, 1914-18, was peculiarly interesting to the du Ponts because of their already established interests in benzene and other basic coal-tar crudes employed in compounding such high explosives as TNT, TNX, and picric acid. Mar. 1916 du Pont chemists began research on dye intermediates. Lammot du Pont was transferred from black powder operations and placed in general charge of dyes, paints, plastics, and miscellaneous chemicals, the interests that weighed heaviest in the Company's future. Early in 1917 the first dye plant unit was authorized at Deepwater Point, N. J.

The name was prophetic. A total investment of $7,000,000 was contemplated. More than treble that sum was invested in dyes during the next five years. Not till 18 years later, after $43,000,000 had been risked, did the aggregate earnings from dyes and related chemicals offset the losses. In 1919 the plant produced the first four or five of fast vat dyes to be made in the United States. By 1923 it was a major unit of the newly established American dyestuffs industry. More than 500 individual dyes, as well as a wide variety of related organic chemicals, including some 100 rubber chemicals and synthetic camphor, were being manufactured by du Pont in 1940.

Paints are but a few steps from dyestuffs in the wide application of color to modern living. Until the mid-1920's, the slow-drying qualities of available paints and varnishes were responsible for one of the worst bottlenecks in the mass production of goods. Some automobile makers had as many as 15,000 car bodies impounded in drying rooms at one time in the course of applying the 22 separate coats of primers, surfacers, rough-stuff, glaze, color, and varnish then necessary for an automobile finish, a finish that was usually cracked and shabby in six months. Locomotives and ships, bicycles and steel bridges, farm combines and furniture, broomsticks and lead pencils, alike waited upon paint to dry.

Du Pont chemists in 1923 answered the growing problem of paint with the introduction of Duco pyroxylin lacquer. This reduced the finishing time on automobiles from days to hours and provided a finish that was as durable as the car itself. The invention did more than revolutionize methods; it changed the trend of thought in the coatings industry. Progressive manufacturers everywhere now sought to improve all types of finishes via scientific research. Du Pont followed Duco with the Dulux series of synthetic resin enamels, introduced in 1927 and later widely amplified.

The manufacture of rayon, entered in 1920, was a logical extension of the Company's long interest in cellulose by way of smokeless powder. Du Pont began by buying the American rights to a French process and erecting a viscose yarn plant at Buffalo, N. Y. At once an intensive research program was inaugurated to improve the product. As that decade ended, du Pont owned three viscose yarn

plants and one acetate process plant, and stood second in volume among the 16 rayon-producing companies in the United States.

Cellophane cellulose film was also first produced by du Pont at Buffalo under French patent rights acquired in 1923. The early film, costing $2.65 a lb., was a luxury wrapping. However, again an aggressive research program was launched which in a few years made cellophane a household word. Twenty consecutive price reductions in 15 years brought the selling price down to 12% of the original price. A moistureproof film was invented, vastly broadening cellophane's usefulness. By 1940 the original plant at Buffalo had become the parent of six other factories and the sparkling transparent film had become an integral part of American life.

Cellulose also led du Pont logically into the manufacture of the pyroxylin plastics, begun through the Arlington Co. purchase in 1915. And the chemical evidence was soon overwhelming that plastics, as such, might lead anywhere if one's research chemists were able to realize upon only a fraction of the possibilities. First came Pyralin cellulose nitrate plastics, soon to be followed by Plastacele cellulose acetate plastics; Lucite methyl methacrylate resins; and then Butacite polyvinyl acetal resin. These were followed by polythene in 1944, and Teflon tetrafluoroethylene resin in 1946.

Research on synthetic rubber was started in 1925. The results, announced in 1931, became tangible in 1932 when neoprene was introduced to industrial markets. By 1940 it was impossible to name an industry in America that was not employing neoprene in many of its most important operations.

The synthesis of ammonia from air, coal, and water was another logical du Pont chemical interest based on its continuous use of nitrates as a raw material. The venture, begun in 1925 at Belle, W. Va., was 10 years under way before it showed a dollar of profit. By that time more than $27,000,000 had been invested.

The importance of heavy chemicals in its general chemical structure was one reason du Pont purchased Harrison Bros. & Co. in 1917. Acquisition of the Grasselli Chemical Co. in 1928 further emphasized this importance. Grasselli, one of the oldest and largest producers of heavy chemicals, became a separate du Pont manufacturing department, retaining it own name. Here were early established the Pest Control Laboratories for researches on insecticides and fungicides.

The Roessler & Hasslacher Chemical Co., added in 1930, was another old-line producer of raw materials essential in du Pont operations. Founded in 1882, R. & H. furnished chemicals for the manufacture of dyes and tetraethyl lead. It was also prominent in electrochemicals and specialized chemicals for electroplating, metal cleaning, bleaching, refrigeration, ceramics, and other uses. This company, too, became a major du Pont manufacturing department.

Early in 1928 fundamental research was started by the du Pont Co., under Dr. Wallace H. Carothers, described by Dr. Roger Adams as one of the most brilliant students ever granted the doctor's degree by the University of Illinois. Carothers and his associates worked on the synthesis of neoprene, but their greatest contribution was nylon, announced by du Pont in 1938. The first nylon hosiery for women, exhibited at the San Francisco and New York World's Fairs in 1939, created a national sensation. By coincidence, the date was the 50th anniversary of the first exhibition of Chardonnet silk at the Paris Exposition in 1889.

Placed on sale to the public in 1940, nylon hosiery was in such spontaneous demand that manufacturing facilities had to be immediately enlarged. Experiments indicated innumerable other uses for nylon, from self-lubricating bearings for machinery to aviation parachutes. Few major inventions have been so markedly successful from their outset or were introduced at so fortuitous a time.

Primary changes occurred in du Pont management as the Company entered its

139th year. Pierre S. du Pont retired as chairman of the board, May 20, 1940, Irénée as vice-chairman, and president Lammot became the new chairman. Walter S. Carpenter, Jr., for three decades in the du Pont employ, was elected president. For the first time since 1834-37 a man other than a du Pont was the administrative chief of the Company. A new cycle had begun. The dream of 1902 had been realized. More than 70,000 investors, including 4,000 employees, now owned Company stock. The upper executive staff now numbered at least 50 men. Physically, the Company's structure was made of 79 plants in 25 states, producing hundreds of diversified chemical products. Total assets were approximately $935,000,000. On this basis du Pont entered World War II.

The Company's wide diversification was reflected in the variety of goods and services it supplied during the war period, ranging from chemicals for heavy armament to household cement. Du Pont technologists worked on incendiary bombs and shoe soles. They built plants on sites covering thousands of acres and produced nylon filaments of spider-web fineness. In contrast to World War I, when explosives made up approximately 85% of the du Pont effort, military explosives accounted for less than 25% of the Company's total production in World War II, although production was several times that of the previous war.

A mechanized war machine demanded rayon and nylon tire cord, synthetic rubber to replace the loss of the natural product, petroleum additives for gasoline and fuel oil, and heavy chemicals for industries producing combat equipment. Du Pont helped furnish them. Air power called for hundreds of special chemical materials—plastic enclosures, finishes, ingredients for high-octane gasoline, tire yarn, synthetic rubber, and high-tenacity rayon for self-sealing gas tanks. Nylon replaced silk for parachutes. As many as 86 chemical products from one du Pont plant alone went into the building of a superfortress.

To a nation at home went commercial explosives to mine coal and metals, rayon for clothing and other textile necessities, finishes to protect property, and such other chemical products as could be spared to support the domestic front. Fertilizers, fungicides, vitamins, and insecticides helped swell agricultural production; refrigerants, mold inhibitors, and special packaging materials safeguarded perishable foods.

The determination to do everything possible for the health, comfort, safety, and protection of combat personnel necessitated the use of a great variety of du Pont materials: Freon (fluorinated hydrocarbons) for refrigeration and aerosol antimalarial units; nylon for netting, hammocks, and special apparel; gasproofing and decontamination materials; neoprene for life rafts and protective clothing; strontium nitrate for signal flares; water purification chemicals; flameproofing and waterproofing compounds; and new insecticides such as DDT, which the Company was among the first to manufacture. To the medical corps went X-ray film, peroxides, disinfectants and germicides, plasma filters, plastics for prosthetic and orthopedic surgery, nylon surgical sutures, and the ingredients of sulfa drugs.

The Company undertook many highly specialized assignments, including a major part in the atomic energy operation; organization and execution of an explosives program treble that of World War I; the assistance to Remington Arms Co., a du Pont subsidiary, in developing the greatest small-arms ammunition output in history.

Total cost of war facilities engineered, designed, and constructed for the Government by the du Pont Engineering Department was $1,034,000,000. This involved the building of 54 plants at 32 different locations, costs ranging from less than $70,000 to $350,000,000 for the Hanford Engineer Works atomic energy project. Nearly half this construction program was to meet military explosives require-

ments. Purchase of a number of sites for government plants totaled approximately 30,000 acres in a dozen states.

The Company also built for the Government a neoprene synthetic rubber plant at Louisville, Ky.; an ammonia-methanol plant at Morgantown, W. Va.; two Chemical Warfare Service plants at Niagara Falls, N. Y., and New Martinsville, W. Va.; a Navy chemical plant at Dresden, N. Y.; and erected on its own properties numerous special facilities financed by the Defense Plant Corp., the Office of Scientific Research Development, and other government agencies. Design, procurement, and consultant services were furnished in connection with a large number of other government-financed plants, including the Rocky Mountain and Picatinny Arsenals, five TNT plants built and operated by other companies, and four plants to manufacture small-arms ammunition by Remington Arms.

From an organization of 5,253 in Dec. 1939 engineering and construction personnel rose to a peak of 54,800 in Aug. 1942, at the height of the explosives program. A second peak of 51,710 was reached in June 1944, as the Hanford atomic energy program neared completion.

The largest single undertaking by the Company during World War II was in the atomic energy project: to design and construct a small-scale pilot plant at the Clinton Engineer Works in Tennessee, and to design, build, and operate a large-scale plant known as the Hanford Engineer Works near Pasco, Wash., for the production of plutonium. This work was a complete departure from chemical manufacturing. Plutonium, discovered in 1941, had been made before only in microscopic laboratory quantities. Unique in conception, huge in scale, the entire Hanford project placed upon the Company an assignment of formidable proportions. It was fulfilled according to plan. The entire compensation for both projects was a fee of $1, and, at the Company's own request, it was stipulated that no patent rights growing out of this work should accrue to du Pont.

The military explosives production program assigned the Company was the largest ever undertaken. Between Dec. 1940 and Aug. 1945, du Pont produced approximately 4,500,000,000 lb. of military explosives, three times its 1915-18 output and 20% above the entire volume used by all Allies during World War I. This included more than 2,500,000,000 lb. of smokeless powder, nearly 1,500,000,000 lb. of trinitrotoluene, 110,000,000 lb. of tetryl, and nearly 200,000,000 lb. of RDX compositions. The number of employees on V-J Day totaled 61,300 in du Pont operations; 36,700 in government-owned plants operated by du Pont.

Earnings per share during the war years declined 21% below the 1939-41 average, and 5% under the 1936-38 level. Fees from war plant operation and construction amounted to less than 2.7% of the total net operating income. Despite almost universally rising costs, the trend of the Company's sales prices was generally downward, the average being about 5% less at the war's end than in 1939.

In Jan. 1948, Walter S. Carpenter, Jr., resigned as president of the Company, and was succeeded by Crawford H. Greenewalt, who joined the organization in 1922 as a chemist in the Philadelphia works. In a letter to the Company's stockholders, Carpenter explained:

"This action today marks the fifth time since the start of this century that the president of the Company has resigned from that office at the age of sixty or less, and has been replaced by a younger man. Such a policy contributes to the revitalization of the administration of that most important office. . . . Since the end of the war the Company has liquidated its wartime activities, has reconverted its operations and organization to peacetime endeavors, and has made important strides in its postwar developments and construction program. . . ."

DUREZ PLASTICS & CHEMICALS, INC., was founded in 1921 by its president, Harry M. Dent, previously a research chemist for E. I du Pont de Nemours & Co. With a fellow chemist, he set up a small research laboratory at Woodside, N. J.

Early research was directed toward finding a plastic molding compound suitable for use as a type face. As a result of his research and observation of manufacturing methods, Dent was convinced there was an opportunity for a manufacturer of plastics on a mass production basis. He decided on phenolic plastics because potentially they appeared to have the widest commercial applications of the plastics then made. Moreover, there were only three relatively small producers. In 1922 the business moved to North Tonawanda, N. Y., which had the advantages of having the largest supplier of wood flour and a lake port.

In 1939 the Company was refinanced and changed its name to Durez Plastics & Chemicals, Inc. Next year it completed its own phenol plant. The Company's wartime activities required no major modifications in production facilities, and there was, therefore, no serious problem of reconversion postwar. Approximately 3% of the 1943 sales were under prime contracts for the Government and about 48% went into the war effort.

Throughout its history the Company has concentrated primarily on phenolic plastics. It produces molding compounds, industrial resins, and oil-soluble resins, under the trade name Durez, for use in paints and varnishes. In Jan. 1947 an extensive plant construction program initiated in the latter part of 1945 and involving a capital investment of several million dollars, was nearing completion. The Company employs about 700 people.

EASTMAN KODAK COMPANY was initiated in 1877, when a young bank clerk in Rochester, N. Y., bought $94.36 worth of "sundries and lenses" and paid $5 to a local photographer for lessons in the "art of photography." The enthusiasm that impelled George Eastman to make this investment was not fleeting and he began a thorough study of photography, read textbooks of chemistry, and subscribed to photographic publications. In an English magazine he read a discussion of the relative merits of a new gelatin "dry plate" as compared with the wet plate, and he began to experiment in his mother's kitchen sink. Soon he began making very good dry plates and had invented a machine to coat them mechanically. In 1880 he went into the photographic business, in a room over a music store, not far from the present Kodak headquarters. Each night found him in his "factory," preparing the emulsion for his plates. The enterprise was immediately successful and the following year he left the bank and formed a partnership with Henry A. Strong: the Eastman Dry Plate Co.

In 1884 Eastman introduced a paper roll film, coated with a sensitive layer and then, after exposure and development, greased to make it more transparent and printed, by contact, on another piece of paper similarly coated. Unsatisfied with this film, Eastman devised a "stripping film" following considerable experimentation. This film came into general use and was supplied with Eastman's most famous product, the Kodak, introduced in 1888 with the famous slogan, "You press the button, we do the rest." Meanwhile, Eastman was ceaselessly experimenting towards the manufacture of a transparent, flexible film which would eliminate the need for stripping the picture from its base. In 1886 he engaged a young chemist expressly to study the problem—one of the earliest recorded instances of an American manufacturer employing a full-time research chemist.

Aug. 1889, Eastman's first transparent roll film went on the market. The trans-

parent material was obtained by dissolving nitrocellulose in methanol and adding camphor together with fusel oil and amyl acetate. The film base was made by coating the solution or "dope," as it is still called, on tables of plate glass about 40 in. wide and 200 ft. long. The material was dried on the tables. Then a substratum of sodium silicate, and later of gelatin, was applied. Following application of the substratum, the room was darkened and the gelatin silver bromide emulsion was spread on the support. The film was later stripped from the tables by a simple, hand-operated winding device, cut into various widths and spooled.

A few months after the introduction of this first transparent film, Eastman received a letter from the Edison laboratories which read: "Enclosed please find sum of $2.50 . . . due you for one roll Kodak film which please accept thanks." And in West Orange, N. J., when Edison saw that roll of film he had said: "That's it. We've got it. Now work like hell!" He recognized that the Eastman film established amateur photography as we know it today, and made possible the motion picture industry.

Eastman's appreciation of the worth of trained scientists to the photographic industry is evidenced by a letter writtten in 1890 to the head of the organization in England: "It will not be long before your concern will need a practical chemist. The best way to do it is to make application to the professor of chemistry in some good technical school and have him recommend two or three first-class boys. If he is any good, he will be the most profitable man you can hire."

Up to 1898 the nitrocellulose for Eastman's film was supplied by an outside manufacturer, but that year the Company began to manufacture its own supply in a chemical plant at Kodak Park, the Eastman film and sensitive goods factory at Rochester, largest factory of its kind in the world.

The quest for nonflammable film is the story of how a hardwood distillation plant developed into the Tennessee Eastman Corp., a subsidiary engaged in the large-scale manufacture of a diverse line of chemicals. During World War I the Government needed large quantities of methanol and Eastman Kodak's supply of that raw material was seriously diminished. To insure a steady supply of certain raw materials in the future, the Tennessee Eastman Corp. was organized in 1920, with Perley S. Wilcox as vice-president and general manager, to buy an existing hardwood distillation plant at Kingsport, together with sufficient timberland and timber rights to allow for sizable expansion of chemical manufacturing operations. In addition to methanol, the Kingsport plant produced acetate of lime, acetic acid, wood creosote oils, charcoal, and other products.

Meanwhile, at Kodak Park, experiments begun in 1906 towards the manufacture of a cellulose acetate film base were resumed following World War I (during which Eastman Kodak supplied cellulose acetate for the American and British Air Forces). A commercially practical cellulose acetate film was eventually produced, using purified cotton linters, as in the case of nitrocellulose. To permit large-scale manufacture of the new safety film, production of cellulose acetate was transferred to the Tennessee Eastman plant early in 1930.

Active research at Tennessee Eastman has led to many new products and important new markets. Today the production of cellulose esters and hydroquinone for photographic purposes represents a relatively small but important part of the plant's output. In 1931 production of acetate yarn started and now the Company is one of the largest producers of it in the world. Koda—acetate filament yarn—and Teca—crimped acetate stable fiber—are familiar names in the textile field. In 1937 the Company undertook to manufacture acetate dyestuffs. In 1932 a cellulose acetate plastic was introduced under the trade name of Tenite. Improved molding compositions—Tenite II, a cellulose acetate butyrate plastic, and Tenite III, cellu-

lose acetate propionate plastic—were later added to establish Tennessee Eastman as a leading producer of cellulose ester plastics.

When hydroquinone operations were transferred to Kingsport in 1930, the entire output was used in the photographic field, but now large quantities are used as an antioxidant by the synthetic and natural rubber industry. Hydroquinone and derivatives, such as the ethers, find important use as gasoline inhibitors and as antioxidants in certain oils. One of the by-products in hydroquinone manufacture, manganese sulfate, is sold under the trade name Tecmangam for use in fertilizer and poultry feed. In addition to the products mentioned above, acetone, ethyl acetate, acetaldehyde, alcohol denaturants, triethyl phosphate, and several plasticizers are being supplied to the chemical industry.

The work of Kodak's research laboratory, established at Kodak Park in 1912 under Dr. C. E. Kenneth Mees, is classified under three broad headings: fundamental research; development work on new materials, processes, and apparatus; and work on problems arising in connection with the manufacture and use of Company products. In addition to the Research Laboratory, there are more than 30 laboratories at Kodak Park and many others in the other Eastman plants.

Numerous photographic chemicals not readily available from the trade are manufactured at Kodak Park—a precaution, as in the case of methanol, dating from World War I days when, since most of the chemicals then in use were imported, the very foundations of photography were threatened. Pyrogallic acid, then an important developing agent, was the first photographic chemical made at Kodak Park. It was soon followed by hydroquinone, elon, and other organic chemicals required as developers, sensitizers, dyes, and antifogging agents.

An allied Kodak activity of tremendous importance to research workers and a major factor in promoting chemical knowledge, is the Synthetic Organic Chemicals Department, established under Dr. Mees in 1918, to supplement work at the University of Illinois. The first published list of the laboratory contained some 150 items; the most recent catalog lists more than 3,000 different chemicals—and more than 99% of these, including all the important ones, are of American manufacture. The work of the Synthetic Organic Chemicals Department is threefold: first, the synthesis of compounds required for laboratory purposes; second, the purification of technical-grade chemicals obtained from other manufacturers; and third, the distribution in small quantities of such technical chemicals in the form in which they were purchased. Many new syntheses have been developed by the Department, particulars of which are freely released to interested chemists. In turn, outside chemists are invited to cooperate with and advise Kodak's staff.

Eastman Kodak has a large and varied chemical industry, manufacturing materials for use in its own products. It makes the gelatin which it uses in the manufacture of emulsions, in plants at Rochester and Peabody, Mass. It manufactures its own silver nitrate—and is one of the largest users of bullion silver in the United States after the U. S. Mint. It has paper mills devoted to the manufacture of raw stock, the base for photographic printing paper, and for which extraordinarily high standards of chemical purity and mechanical properties must be maintained. Lacquers, varnishes, and paints, are also made for use in the Company's plants, and a large factory is devoted to the manufacture of chemicals used in the processing of photographic materials, and in particular to the preparation of packaged chemicals.

Out of early work of Dr. K. C. D. Hickman in the Kodak Research Laboratories on high-vacuum technology has developed the company known as Distillation Products, Inc., jointly owned for some years by Eastman and General Mills, and concerned with the manufacture of vitamins A and E by molecular distillation.

and of equipment for high-vacuum technology. Distillation Products became a subsidiary of Eastman Kodak Co. in 1948 when the latter purchased the General Mills interest.

In recent years Eastman Kodak has worked out a method for making oxidized cellulose which is being prepared on a large scale for use in the medical field. As a service to scientists, a number of special products are manufactured in addition to the organic chemicals. Some of the most recent are the isotopes carbon 13 and nitrogen 15, which are used as biological tracers. Eastman tends to manufacture those chemical products which will be used in the preparation of the materials which it sells, to develop new products in the light of experience gained in the manufacture of those of photographic interest, and to make special chemicals as a service to scientific research workers.

EATON CHEMICAL AND DYESTUFF COMPANY, of Detroit, is basically a distributor of chemicals and dyestuffs, but it also manufactures many specialties and maintains two research laboratories. In addition to its offices, main warehouse, and manufacturing facilities in Detroit, the Company has branch manufacturing facilities and warehouses in Windsor and Toronto, Canada. It employs about 100 persons in all, including 20 salesmen. It serves principally the Detroit, southern Michigan, Toledo, Windsor, Toronto and western Ontario industrial areas, doing a considerable volume of business throughout the entire United States and Canada in its own specialties.

The business began in 1838, when Theodore H. Eaton of Skaneateles, N. Y., a partner-salesman for a Buffalo drug firm, purchased the Riley Ackerly drugstore in Detroit, then a city of less than 8,000. He sold medicinal preparations, dyewoods, chemicals, and spices at retail and wholesale until a fire destroyed his store in 1848, when young Eaton constructed a four-story warehouse and store on Detroit's main street, Woodward Ave., near the river front, where headquarters were maintained for 78 years.

Shortly after 1850, retailing was discontinued. Distribution of cleansing and coloring agents and leather-finishing materials formed the core of the business—alkalies, soaps, and paints for lake boats that docked at Detroit, and dyewoods and chemicals for woolen mills and tanneries in and near Detroit and Windsor. Most of the new towns then springing up in Michigan, Ohio, and Ontario had either a woolen mill or tannery, or both. With horse and buggy, Eaton visited these industries often and established his firm as a source of chemical supply. On the same trips he also sold materials to country stores, principally chemicals for spraying and fertilizing, potash lye for making household soap, and "Prussian" blue for laundering.

He purchased from most of the prominent chemical manufacturers and importers of the period, many of whom have since been absorbed in mergers. He also imported many chemicals, dyewoods, and later aniline dyes direct; acquired an interest in two dyewood mills, one in Boston and another in Glasgow; and frequently visited the foreign business houses with which he dealt. All the early coloring materials sold were natural dyestuffs, such as catechu, japonica, red argols, flavine, fustic, gambier, and logwood. Besides dyewoods, the firm stocked a large assortment of chemicals and made an early venture into the manufacturing process, curing raw logwood chips with ammonia on a large scale.

The founder's son, Theodore H. Eaton, Jr., entered the business as an apprentice in 1859, and was promptly sent abroad on business. He returned with a sample of aniline scarlet, one of the first importations of a coal-tar dye into North America. In 1866 Eaton, Jr., was admitted to partnership, and the firm name was changed

to Theo. H. Eaton & Son. It was not long before the firm was importing many aniline colors, and these gradually replaced most of the natural dyes in Eaton's trade with woolen mills and tanneries. When Eaton died in 1888, his son became sole owner, and in 1890 formed a partnership with Benjamin F. Geiger, an old employee. Thereafter a new market for dyestuffs developed—the business of garment redyeing, which was increasing in the areas the firm served.

Shortly after the turn of the century, Rufus W. Clark, Jr., who had joined the Company's laboratory staff in 1899, developed a benzine soap for dry cleaning, which was one of the first soaps of this type marketed in the United States or Canada. Good distribution channels were readily established, as dry cleaning was adopted by the steam laundries and garment dyers with whom the firm was dealing. To aid this new industry, the Company helped establish the National Association of Dyers & Cleaners in 1907, now the National Institute of Cleaning & Dyeing. It has since supported many other similar organization.

As woolen mills and tanneries grew less important around Detroit, the Eaton business found new and expanding fields, such as pharmaceutical manufacturers, stove, automobile and automotive parts manufacturers, and scores of other new industries.

The Company has also gone further into manufacturing. It not only mixes dyes for many special uses, but also manufactures a variety of soaps, spotting solvents, leather-finishing materials, laundry blues, and paper-ruling inks. By the beginning of the 20th century it was distributing chemicals to practically every type of industry: coloring materials for flavoring extracts, carbonated beverages, and pharmaceuticals; chemicals for dairies, distilleries, breweries, bakeries, etc.; colors for dyeing broom corn and baskets; water, spirit, and oil-soluble stains for furniture and toy manufacturers; dyestuffs and chemicals for textile mills; a complete line of chemicals and general supplies for commercial laundries, garment dyers, and dry cleaners; photographers' and photoengravers' chemicals; acids, cyanides, etc., for the fumigators and exterminators; oils, petrolatums, and colors for pharmaceuticals and cosmetics; alcohols, anti-freeze, and proprietary solvents; synthetic detergents and penetrating agents; aromatic chemicals, perfume oils, and flavoring materials; acid, basic, direct, union, and acetate dyes; chemicals and gases for refrigeration equipment; chemicals for the petroleum and oil-refining industry; chemicals and metals for electroplating; fertilizers; solvents and alkalies for metal degreasing.

When Geiger died in 1905, Rufus W. Clark became Eaton's partner and business manager. After Eaton, Jr., died in 1910, the firm was incorporated (1911) under the laws of Michigan as Eaton-Clark Co., with Clark as president. Berrien Eaton, grandson of the founder, joined the sales staff in 1915, and was elected president in 1920, at which time Richard C. Hedke became vice-president and managing director; next year Clark became chairman of the board. Following an increase in capitalization in 1921, the Company purchased its present large building on Franklin St. in Detroit for warehousing and manufacturing. In 1927 it erected an adjacent building for office, laboratory, and warehouse. In 1922 a new and larger warehouse was erected in Windsor and later an additional branch established in Toronto. One of the two research laboratories maintained in the Detroit plant has concentrated on developing and testing specialties for the dry-cleaning and garment-dyeing trade; the other, on improving processes in electroplating.

When the Company celebrated its 100th anniversary in 1938, a bronze medal was struck to commemorate the occasion. These medals were distributed to employees and old business friends. The Company is the oldest industrial firm in Michigan. Its growth has been sustained for over a century because it kept pace with the industrial changes that accompanied the growth of Detroit and the Middle

West, as well as Eastern Canada. As new chemical-using industries appeared in the Company's territories, the newcomer's needs were investigated and promptly served.

Rufus W. Clark retired from the business, Feb. 28, 1947, and on Jan. 1, 1948, the name of the Company was changed to Eaton Chemical and Dyestuff Co. Its officers and executives are: President and treasurer, Berrien Eaton; vice-president, secretary, and managing director, Richard C. Hedke; sales manager, Industrial Chemicals Division, Gerald T. McCray; sales manager, Laundry & Dry-Cleaning Division, Raymond F. McDonald; chief chemist and manager, Dyestuff Division, Rotheus P. Cole; assistant treasurer, C. L. Elliott; assistant secretary, C. T. Tessens.

ECUSTA PAPER CORPORATION, Pisgah Forest, N. C., founded by Harry H. Straus, has brought to this country a new industry which is giving employment to more than 1,700 people, has made the United States independent of one more foreign source of supply, and has given the American farmer a new cash crop for a waste product. The story of the world's largest producer of cigarette paper is one of chemurgic achievement. In founding this industry, organic chemistry, plant genetics, modern engineering, and individual enterprise have combined.

Until 1939 the bulk of our cigarette paper was imported from France. It was made from old dirty linen rags picked up throughout the Balkans and Central Europe. One man's inventive genius and foresight made this essential commodity available in adequate quantities when the foreign source failed. Harry H. Straus came to the United States as a boy in 1902 to learn the language and business methods. Impressed with the country's possibilities, he remained. He originated corktip cigarettes. Later he formed a connection with a leading Austrian supplier to sell their cigarette paper. When the war in 1914 cut off this source of supply, Straus made a new contact with a French mill. In 1930 he acquired an interest in another French mill. By 1937 some 26 French factories were furnishing 90% of cigarette paper used in the United States.

Remembering 1914, in 1932 Straus started experiments in South Carolina for raising fiber flax, the variety grown in Europe for textiles. Although not successful, these experiments did furnish flax with which to start the development of the paper processes. Investigations resulted in an attempt to utilize the straw of seed flax, which was first defibered. One by one the problems were overcome, agriculturally and chemically, until pilot-plant runs were successful; and in 1937 paper from American seed flax fiber was made in France. Particular credit for this goes to the late Dr. Fritz L. Straus, brother of the founder. On Oct. 1, 1944, Milton O. Schur succeeded Dr. Straus and is now director of research.

War was imminent in Europe. The cigarette manufacturers, realizing that Straus was no alarmist, loaned him $2,000,000. Since most of the cigarettes are made in North Carolina, a site was bought there after 59 different sites had been considered. The important factor was water. The Ecusta Paper Corp, is situated on a flat area where the Davidson River comes tumbling out of the Pisgah National Forest, three miles from Brevard, N. C. Samples of this water were sent to France for mill tests; it was found soft and free from minerals—iron, for example, would give the paper a taste. Because Ecusta is located at the entrance of the National Park, there is no danger of pollution of the water above the plant. "Ecusta" was selected because it is derived from the Cherokee language meaning "rippling water." Seventeen buildings were constructed and French experts were brought over in May 1939, to erect the machinery and teach the art of making cigarette paper. In the mountains of western North Carolina was carried on the strangest

industrial school ever opened. One by one the machines were put into operation by the Frenchmen. Near by stood the pupils, and between the two groups were interpreters. Sept. 1, 1939, the very day Hitler invaded Poland, the first commercial cigarette paper made in the United States from flax fiber roled off the machines of the Ecusta Paper Corp.

Since that day the factory has more than doubled in size and capacity. The output is now over 50 tons of paper a day, and with the completion of another new machine, now being installed, the production will be over 60 tons. Ecusta produces daily enough paper to make over a billion cigarettes. A separate operation produces enough booklets daily to make 150,000,000 cigarettes, "roll-your-own" type.

Paralleling construction of the paper mill, efforts were directed towards obtaining a dependable source of fiber. An associated company, the California Central Fibre Corp., was incorporated in 1937 and immediately construction was started on a mill at El Centro, Calif., for decorticating Imperial Valley flax straw. Central Fibre Corp. was similarly incorporated at the same time for flax fiber supplies in Minnesota. Straus was the guiding hand behind both these endeavors. Ecusta keeps on storage about a year's supply of flax fiber. Besides shipping its cigarette paper all over the world, Ecusta is now manufacturing writing, air mail, and fine text papers from flax. For the one purpose of fine flax papers, the consumption of flax straw, the product that once had to be burned, has risen to around 300,000 tons per year.

Behind the expansion of flax paper production Straus maintains a comprehensive laboratory and research organization. A geneticist on the staff has produced thousands of hybrid varieties. Constantly sought for are varieties that yield seed more abundantly, grow with better qualities of straw, and resist disease more vigorously.

The investment has grown to about $15,000,000, and the present directors of the Ecusta Paper Corp. are Harry H. Straus, Thomas N. Word, John W. Hanes, Robert M. Hanes, and Walter M. Schwarz.

EDWAL LABORATORIES, INC., was founded in 1932 by Edmund W. Lowe and Walter S. Guthmann, from whose first names is derived its own. The partnership had first been proposed by Guthmann when he and Lowe were designing a carbon dioxide generator for microanalysis. The partners, both Ph.D.'s from the University of Chicago where they had studied and done research under Prof. Julius Stieglitz, constructed a laboratory on the second floor of an ancient house at 3420 Indiana Ave., in the center of Chicago's Negro district, and accumulated some laboratory equipment and a few orders.

The basic idea was to make new, commercially unavailable chemicals, usually on a relatively small scale, for industrial, government, or university laboratories which needed them for experimental or pilot-plant work. Even in the depression there was an appreciable demand for such chemicals. Considerable business developed in making special chemicals on a confidential basis for customers who wished to keep their use of the particular chemical a secret. A start was made in consulting and industrial research work, but the greater emphasis was soon placed on manufacturing and on special jobs which included some chemical production. Two early, rather bizarre assignments were to make flammable wings for the "flame dancer" and set up equipment for causing artificial smoke to pour from the "volcano" on Frank Buck's monkey island, both at the 1933 Chicago World's Fair.

By the summer of 1934 business was good enough to warrant moving to a more modern building on 732 Federal St., where high-pressure steam was available for process work, and on July 1 Edwal Laboratories was incorporated. At that time the

Company's chief products were phloroglucinol and allyl alcohol and its derivatives. Since Lowe was a photographer, prepared developers to meet the demand of the new "miniature camera" boom were also marketed. Production of these chemicals was expanded and in 1937 the manufacture of phenylmercuric nitrate, acetate, etc., was begun. That summer the firm moved to a larger space on the 12th floor of the same building.

Between 1937-40 uric acid, alloxan, allantoin, hydrazine sulfate, sodium cyanate, semicarbazide hydrochloride, and ammonium thiosulfate were added and the consulting and industrial research division expanded, with the result that in Jan. 1941 a building at Ringwood, Ill., was purchased. An explosion at Federal St. interrupted chemical manufacturing for several months, but it was possible to start production at Ringwood in April. The new plant was incorporated separately under the name Ringwood Chemical Corp. in Feb. 1941. Here some of the early chemical operations had to be conducted out in the open and the "citified" chemists from Chicago still remember the times they operated kettles while watching the moon come up through the near-by spruce trees.

Since 1941 new buildings for warehousing, flammable storage, photographic packaging, laboratory and office use have been erected at Ringwood and additions to the original manufacturing building made until the property now occupies 27½ acres. The manufacture of a considerable list of new fine chemicals has been undertaken, chiefly for the pharmaceutical, diazotype reproduction, and photographic fields. All but the photographic chemicals are sold industrially. The photographic chemicals and specialties are marketed by seven jobbers throughout the country and sold through photographic dealers under the Edwal name.

The first officers of Edwal were Edmund Lowe, president; Walter Guthmann, vice-president and treasurer; Paul H. Leffman, secretary. During the war Guthmann and Leffman entered the Armed Forces and William B. Guthmann became vice-president and assistant treasurer, while Ferdinand J. Mann (Leffman's law partner) became secretary. Jan. 1, 1947, Edwal absorbed the Ringwood Chemical Corp. and the officers became: Lowe, chairman of the board and director of technical activities; W. S. Guthmann, president; Waldersee B. Hendrey, vice-president; Henry D. Hirsch, treasurer; and Mann, secretary.

EMERY INDUSTRIES' founder, Thomas Emery, Sr., was born in England, Dec. 15, 1798. Although holding a responsible position in a London bank, the lure of America brought him to Cincinnati where, in 1840, he established the business which almost a century later became Emery Industries, Inc. His first product was lard oil, used principally for illumination, but soon he began manufacturing tallow candles. He did a sizable business in these two items. During that period the word "Porkopolis," spoken in jest, became significant because Cincinnati was a principal meat-packing center, which explains Emery's early interest in fats and oils. Two of his five children were ready to carry on the candle company when he died, Dec. 30, 1857. Thomas J. Emery, Jr., born in Newport, Wales, 1830, and John J. Emery, born in Cincinnati in 1835, were active both in the manufacturing unit and in a realty company which operated throughout the United States.

During its early history the Candle Co. moved first to escape the ire of citizens who objected to the unpleasant smells associated with processing fats and oils. However, each location was selected close to the Ohio River, the principal means of transportation. Recurring floods and the better transportation led to the establishment of the factory in a Cincinnati suburb now known as St. Bernard, where in 1885 a "modern" plant was built on the banks of the Mill Creek, affording process

water but not transportation, adjacent to the main line of the railroads serving Cincinnati.

The first tallow candles were made by the crude methods commonly practiced by the housewife and despite the trade name, Adamantine, they were neither hard nor shiny. We cannot be sure when the discovery was made that the "solid" ingredient in fat is glyceryl stearate. Tallow is greasy because its major component is the glyceryl ester of oleic acid, a liquid fatty acid. Glycerin being a trihydric alcohol, forms mixed glycerides, part triolein, a major part the glycerides of two, possibly three different fatty acids. So the Emery Candle Co., as it was called after 1850, discontinued the manufacture of tallow candles to make sturdy, white dripless candles in which stearic acid was the principal ingredient. The by-products oleic acid and glycerin were marketed for the manufacture of soaps and the lubrication of wool yarn. Emery Candle controlled about 75% of the latter business east of Pittsburgh where most of the woolen mills were then located.

In 1887 the Company was incorporated in Ohio with a capitalization of $500,000. Much early history is revealed in the records of July 1889, when J. J. Emery and Thomas J. Emery, Jr., made numerous interpretations of their affairs for a group interested in purchasing the plant. The property and equipment were located in several buildings on 8.9 acres. The stillhouse was equipped with both copper and iron stills with the usual number of tanks, condensers, water and steam connections. The tankhouse, a name used to this day, housed the department which separated the fat into its component parts under heat and pressure in autoclaves. Alongside stood the glycerin house containing several tanks to evaporate the "sweet" water, leaving a crude concentrated glycerin. Eight tubular boilers including superheaters and preheaters equipped the boilerhouse. Until about 1940 fatty acids were pressed to separate the liquid component from the solid acids. The same process prevailed in 1889 and the equipment found in the pressrooms included 12 horizontal hydraulic hot presses and six vertical cold presses along with the necessary equipment to establish a pressure of some 3,000 lb. to the square inch. There were 6,000 enameled iron pans to mold the cakes in the form in which they were pressed. The candle plant contained 51 molding machines of almost the same type used today. Instead of four to eight cylinders, the modern machine may contain as many as 250 made from block tin which takes a high polish which in turn is imparted to the surface of the candle. Instead of depending upon air cooling, these machines are fitted with steam and water. The candles are ejected by mechanically operated pistons which also serve to center the wick. Modern wick is a carefully braided and chemically treated cotton to make smoother burning, self-consuming, self-extinguishing wicks. The oleic acid was delivered from the pressroom to the red oil house for further processing before barreling. There were office buildings, cottages for the workmen, stables for the animals, and several artesian wells.

Coal was delivered to the factory at $1.40 per ton and gas was manufactured from gasoline at 60¢ per 1,000 cu. ft. The process for the latter operation was not described. Total production was just short of 6,000,000 lb., almost 50% of which was Elaine, the trade name for oleic acid. About 40% was candles, and the absence of figures for stearic acid indicates that virtually the entire output of this acid was used in candles. Since the normal ratio of oleic to stearic in fats is approximately 60% liquid acids and 40% solid acids, we can assume that these candles were essentially pure stearic acid. In addition to these two principal products, glycerin and tar or stearin pitch accounted for a little more than 500,000 lb.

The stockholders of the record dated Aug. 7, 1889, were Thomas J. Emery, Jr., J. J. Emery, C. J. Green, Theodore Massman, Robert Mecke (still alive), Dr.

Ernst Twitchell, H. B. Morehead, Herbert Jenney, George Eustis, Balser Werthner, John Walliman, Henry Gruesser, Charles L. Burgoyne, and D. C. Shears. Green, plant manager since 1875, was secretary and treasurer.

Prices paid for raw materials and the selling prices of merchandise now makes strange reading. Tallow was bought for an average price of less than 3¼¢ per lb.; stearic acid sold for 8¾¢, with red oil reaching 4½¢ as its maximum; glycerin was quoted at 8¼¢. Because of lack of refrigeration, the Company operated only during the colder months, for summer heat prevented the manufacture of oleic acids with low titers.

Dr. Ernst Twitchell joined the Company in 1886. His unusual abilities were immediately responsible for changes. In the appraisal made by Green we read, "with the aid of an excellent chemist, we are able to employ lower grades of fat . . . yet maintain the highest reputation for the quality of our goods." But Dr. Twitchell also carried on extensive investigations into the pure chemistry of fats and oils, making advances in the art. It is through the Twitchell process, developed and patented at the turn of the century, that he is best known. This method of hydrolyzing fats at low temperatures in the presence of a catalyst, the Twitchell reagent, revolutionized the fat-splitting industry and was accepted universally.

Emery Candle Co. continued to grow. Unfortunately Thomas J. Emery, Jr., died in Egypt Jan. 15, 1906, while there on business. On Sept. 8, 1908, John Emery died, and control was vested in the directors, who were also active in Thomas Emery's Sons Co., a realty concern with extensive properties in many metropolitan centers. These men, with the year in which they joined the Company, were Robert Mecke (1879), Henry Gruesser (1883; deceased), George Rippe (1883; deceased), Fred R. Elsche (1884), Charles L. Burgoyne (1884; deceased), John H. Hall (1885; deceased), Ernst Twitchell (1886; deceased), E. W. Lynd (1887; deceased), Louis T. Kaiser (1888), Charles J. Livingood (1890), F. J. Schlanser (1891), and Albert R. Burman (1893).

These men operated the Company with Burgoyne as president and Dr. Twitchell as chief chemist, until Apr. 1, 1924, when John J. Emery, Jr., at the age of 26 became president of the Emery Candle Co., a position which he still holds with Emery Industries. He also became president of Thomas Emery's Sons Co. and director of the Twitchell Process Co. For the next several years rapid strides were made to modernize the plant, consolidate operations, and build an extensive research program. In 1916 exclusive American rights to the Petroff patents had been obtained by Twitchell Process to replace the original Twitchell reagent. The surface-active properties obtained by sulfonation of lubricating oil stocks to produce white oil resulted in interesting new uses, so that when the Twitchell Process Co. became a division of Emery Candle in 1929, it importantly diversified the latter's operations. Full combination of activities as Emery Industries took place in 1931.

The products of this new company included several new compounds: the Kontols, "emulsion-breaking" mixtures used principally in the petroleum fields; several oils for processing textiles; an oil to speed the process for manufacturing Sanforized fabrics; an improved fat-splitting reagent, a base for solubilizing mineral oils to prepare cordage oils and metalworking compounds; and emulsifiers and wetting agents for many purposes. To further needed, more extensive research, in 1931 all laboratory facilities were combined in a new laboratory building. One of the first products to gain wide acceptance was Sanitone, a patented dry-cleaning process, replacing "bone-dry" methods with one utilizing sufficient water to remove waterborne soils. As revolutionary was the Emersol process, reduced to scale-plant operations in 1938. This process separates solid fats from their liquid counterparts by selective crystallization. Not only were costs reduced and the disadvantages of

the old pressing methods eliminated, but this method made possible further separation of solid acids into purer constituents. Commercially, it is not important to obtain pure stearic acid and palmitic acids, but it is desirable to produce "fractions" in which one or the other predominates. It is also practical to separate glycerides, so that lard oil is being made by the Emersol process. A second advantage of this solvent separation is that liquid fatty acids with improved drying characteristics can be produced even from soap stocks. Hence selection of raw materials is much broader than with normal pressing operations. Today Emery's entire output of fatty acids is handled in three large solvent-separation units, embodying automatic process controls.

The plastics field did not escape attention of the Research Department. By 1940 Emery had a plan for making two C_9 acids, the monobasic pelargonic and the dibasic azelaic. This was the first time either had been produced commercially. While both acids have specific uses in alkyd resins and plasticizers, part of the production of each is esterified, for example to diethylene glycol dipelargonate and dioctyl azelate. Since 1941 the capacity of this plant has been more than doubled.

During World War II principal production was confined to raw materials for several critical processes and compounds. Fatty acids from every classification were used at one time or another in the synthetic rubber program. Soaps made from both stearic acid and oleic acid were much in demand. Candles for emergency lighting kits were bought in huge quantities by the Quartermaster Corps. There were also many small, and in some cases previously unheard of, uses for fatty acids. Formulas compounded with a sulfonated mineral oil as their base were used to manufacture soluble metalworking oils and textile oils, rust preventives, lube additives, engine-detergent compounds, and many others. Research was not stopped, although much of it was directed toward the war effort. For example, much work was done on oleic acid used in preparing the gel-type incendiary.

Emery Industries continues to manufacture all types of fatty acids. Many processes are quite different from those used before the war. A 1947 addition of an esterification plant permits manufacture of almost any type of fatty ester. A hydrogenation plant has been brought on line. While the research program contains many new products, almost all derived from fatty acids, one has now reached the production stage. This is a C_{36} dimer acid, a dibasic acid consisting of two C_{18} fatty acids crosslinked through double bonds but leaving two degrees of unsaturation. The same process also produces a very pure oleic acid and fatty acids relatively free of linoleic and linolenic acids.

The latest management change indicates another move in the expansion of Emery Industries. The Consumer Products Division combines the facilities of a new candle plant and the sales organization for both candles and Sanitone into one organization handling products sold direct to the consuming public. This contrasts with other operations which are devoted primarily to selling raw materials and/or processing materials to other manufacturers.

The present officers are J. J. Emery, president; A. W. Schubert, vice-president; K. K. Boyd, secretary; and H. W. Altvater, treasurer.

ENGELHARD INDUSTRIES' history is the history of Charles Engelhard. When he came to this country in 1891, he established himself as the representative of the major platinum refiners of Germany, England, and France. Seeing the immense possibilities for the development of the platinum business in the United States, Engelhard acquired interests in some companies and founded others, all of which are now as a group called the Engelhard Industries.

Charles F. Croselmire & Son at Newark, N. J., dating from 1875, was a small

establishment which refined jewelers filings, assayed precious metal sweeps and scraps, refined platinum and worked it into sheet and wire. Charles Engelhard acquired this firm in 1902 and shortly thereafter incorporated it in New Jersey as the American Platinum Works. It comprised not more than half a dozen employees, as contrasted with some 250 today. The company then began manufacturing platinum utensils for chemical industries and laboratories and branched out into findings and settings for jewelers. Special alloys were developed for the dental industry and platinum alloys were introduced in the electrical industry which was then expanding on a tremendous scale. As the chemical industry grew, the American Platinum Works built sulfuric acid condensers and other heavy acid equipment of platinum and gold alloys.

In recent years the company has concentrated on silver products and today holds an important position in the silver industry. Silver sheet, tubing, and rod are supplied to silversmiths and silver anodes and solders go to a large variety of manufacturers. The American Platinum Works also specialized in fountain pen nibs for which it developed new alloys and special automatic machinery.

In 1904 Baker & Co., Inc., was incorporated with Charles Engelhard as general manager and treasurer. Founded about 1875 as Baker & Co., at Newark, N. J., this firm originally manufactured jewelry, but by the 1880's refining and working of platinum metals became its principal activity. It was owned by Daniel W. Baker and his three sons.

Today Baker products are sold in the form of precious metal sheet, wire, and tubing and many other partially manufactured items to meet special industrial needs. Precious metal salts are produced on a large scale for electroplaters. A large variety of Baker platinum and palladium catalysts finds its way to the chemical and pharmaceutical industries throughout the world. Precious metal contacts and thermostatic metal are supplied to the electrical industry and to manufacturers of precious instruments. Precious metal magneto and spark plug points are furnished to the automotive and airplane industries. Baker manufactures thousands of spinnerettes of platinum and gold alloys for the rayon industry. Certain jet-like parts of solid platinum metals built by Baker are used in the manufacture of fiber and wool glass. Innumerable products go to the dental trade.

Baker chemists and metallurgists are constantly finding new uses for platinum. From the large Research and Development Department have come platinum-rhodium catalysts for ammonia oxidation and the important development of electroplating with rhodium. Baker has contributed in no small way to the development of atomic energy.

With growing branches in foreign countries, Baker is now the largest platinum house in the world and employs about 1,500 here and abroad. Baker Platinum, Ltd., in London has expanded until its several plants today manufacture all the products formerly made only at the Newark, N. J., plant. Baker Platinum of Canada, Ltd., in Toronto, manufactures and distributes Baker products in Canada. The Engelhard Industries, Inc., in Rio de Janeiro was established to supply South America and, following the great demands of postwar Europe, branches are being set up in Scandinavia and in Switzerland. Before World War II, Baker had plants in Japan and there is no reason to doubt that manufacture there will one day be resumed. In 1945 Charles W. Engelhard, back from war service, became executive vice-president of Baker & Co., in addition to vice-presidency and directorship in other companies of Engelhard Industries.

In 1905 Charles Engelhard founded the Hanovia Chemical & Manufacturing Co., at Newark, N. J., which was incorporated with him as president and treasurer. In 40 years it has grown from 5 to 500 employees. Its Ceramic Division processes

gold, silver, platinum, and other metals in liquid, paste, and powder form and supplies manufacturers of ceramic and glassware all over the world. A large variety of materials giving off a bright metal finish or a burnished texture or lusters in many colors is made to suit ever-changing fashions and techniques. The Lamp Division specializes in ultraviolet equipment, using a high-pressure mercury arc in a sealed quartz tube. Hanovia perfected this basic element and steadily improved other features of these lamps which are important in medicine and sanitation. Hanovia also makes infra-red heat lamps, short-wave diathermy apparatus, and other scientific equipment from pure and transparent fused quartz. Its products are manufactured by two subsidiaries in England, Hanovia, Ltd., in Slough and Hanovia Products, Ltd., in London, to supply the market within the sterling block.

In 1907 the Glorieux Smelting & Refining Works, precious metal refiners established in Irvington, N. J., in 1888, became part of the Engelhard group of industries and in 1909 the name was changed to Irvington Smelting & Refining Works. Under Charles Engelhard's management the company expanded its activities so that now it refines not only old jewelry and scrap, but crude precious metals direct from the mines. Irvington also converts the copper which it recovers into copper sulfate, which has become an important branch of its business. The silver-refining equipment has been enlarged to a capacity for refining over 60,000,000 oz. of silver annually. The firm is among the five largest refiners of gold in this country. It employs about 350 people.

One of the businesses Charles Engelhard undertook in this country was reselling instruments manufactured abroad. This was stopped by World War I, so Engelhard formed the independent firm of Charles Engelhard, Inc., for the purpose of manufacturing industrial instruments. At first recording and indicating pyrometers, resistance thermometers, and all their accessories were manufactured. In 1921-24 the firm pioneered a new type of instrument for measuring gases based upon thermal conductivity, which was a major improvement over previous methods used. In 1931 an air-fuel ratio analyzer was developed and marketed for use in testing the efficiency of combustion engines. Later came a unit for testing the efficiency of oil and gas burners for domestic heating.

In 1935 Charles Engelhard acquired the Clark Thread Co. of East Newark, N. J., and formed the East Newark Realty Corp. to handle property consisting of 20 acres of land and factory buildings with over 1,000,000 sq. ft. of space. This enterprise has been transformed into a thriving city with about 30 different manufacturing concerns giving employment to approximately 4,000.

D. E. Makepeace Co. of Attleboro, Mass., one of the old New England jewelers dating back to 1886, was acquired by Charles Engelhard in 1941. Founded by Daniel E. Makepeace to manufacture rolled gold and silver and other metals, it was the first factory of its kind in this country. During World War II the Makepeace factory converted to war work, but today it supplies jewelers, optical, pen and pencil manufacturers, and the electrical industry with a large variety of basic precious metal products.

The Amersil Co., Inc., originally called the Sidio Co. of America by its founder, O. C. Trautmann (1912), was incorporated in New York in 1926 and acquired by Engelhard in 1945. Located at Hillside, N. J., the past 14 years, Amersil manufactures fused silica and fused quartz equipment which has found wide application in industries where extreme thermal, chemical, and electrical conditions are encountered. It also maintains an engineering service which will supervise and direct construction of heavy acid plants or wherever Amersil equipment is being installed.

The latest and smallest firm to join Engelhard Industries is the Nieder Fused Quartz Co. at Babson Park, Mass., acquired in 1946. It is operated by Bertold

Nieder and specializes in fused quartz for exceptional requirements in the optical industry, and also certain types of fused quartz equipment for laboratories and research purposes.

ETHYL CORPORATION legally came into being in the summer of 1924, but its real beginning dates back to the time when the "knock" in internal combustion engines first became a problem. Long years of research and laboratory work finally produced the answer: the addition of a small amount of tetraethyl lead to gasoline. This has been termed "the most important automotive discovery" in recent decades, for until the knock problem was solved automotive progress was all but stymied.

Charles F. Kettering, now head of General Motors Research, was first to recognize the seriousness of knock. He encountered the obstacle twice in 1912-14, first in the automotive engine and again in the Delco farm-lighting unit he was then developing. His inventions of battery ignition and the electric self-starter, both introduced on the 1912 Cadillac, were blamed in some quarters as the cause of the knock. But when Kettering met the same problem in a kerosene motor generating electricity for rural homes, he was convinced the fuel, rather than the engine or its parts, was creating the constant "ping-ping-ping." Kettering was forced by the rapid growth of his Delco business to put aside temporarily the study of knock, but in 1916 he turned over the early experiments to a newly engaged assistant, Thomas Midgley, Jr., a recent Cornell graduate, at his Dayton (Ohio) Engineering Laboratories Co., which a few years later was sold to General Motors Corp. That was the start of a fruitful association of the two men, and as Midgley later said, what chemistry he, a mechanical engineer, had learned, was absorbed "on the run" while conducting the knock experiments.

Midgley's first step was to establish definitely that it was the fuel and not the engine that knocked. This required several pieces of test equipment, some of which he had to devise. One of these was the Midgley Optical Indicator, a high-speed recording device which magnified and showed clearly the pressure curve of each explosion inside a cylinder during the split-second of combustion. This indicator established that knock and pre-ignition were two entirely different phenomena.

Determining that it was the fuel that knocked was a simple task compared to the years of research before the best anti-knock was found. When success finally did come, it was through the use of the periodic table of elements, supplemented by a periodic arrangement suggested by Dr. Robert E. Wilson, now chairman of Standard Oil Co. of Indiana. Dr. Wilson's arrangement led to the preparation of the ethyl and phenyl derivatives of several elements whose anti-knock effect was plotted against atomic number. This led the researchers from tin to tetraethyl tin and finally to tetraethyl lead. Midgley is reported to have discovered the anti-knock properties of tetraethyl lead on Dec. 9, 1921. A patent covering its use in motor fuel was applied for Apr. 15, 1922, and granted Feb. 23, 1926. Numerous other patents have been obtained through the years to cover the other ingredients of "Ethyl" anti-knock compound, as well as various phases of its manufacture and use.

Midgley was aided by several leading research men, the closest associate being T. A. Boyd, now head of the Fuel Division of General Motors Research Section. Other contributors included James P. Andrew and Drs. Carroll A. Hochwalt and Charles A. Thomas. Other men might have written off the long search for a knock preventive as a hopeless assignment and a "waste" of time and money, but the faith of Kettering and Midgley, and their support by Alfred P. Sloan, Jr., chairman of the General Motors board, carried through these experiments successfully.

As manufactured today, "Ethyl" anti-knock compound consists chiefly of tetra-

ethyl lead, the active agent, plus ethylene dichloride and ethylene dibromide, which combine with lead during combustion, carrying it off in the exhaust fumes. "Ethyl" gasoline was first placed on public sale Feb. 2, 1923, at a single service station of the Refiners Oil Co. in Dayton, where virtually all the original research was conducted. Since the manufacture and distribution of the product was not a proper function of the GM Research Corp., GM incorporated the General Motors Chemical Co., a wholly owned subsidiary, for this purpose on Mar. 7, 1923, with Kettering as president and Midgley as general manager.

During 1923 "Ethyl" gasoline sold at many service stations in the Midwest. The tetraethyl lead was manufactured at a specially constructed du Pont plant in Deepwater, N. J., which shipped it to Moraine City, near Dayton, for blending with other ingredients by the GM Chemical Co. The method of manufacture, developed by GM Research Corp., involved reacting an alloy of metallic lead and sodium with ethyl bromide at atmospheric pressure.

Early in 1924 Standard Oil Co. (N. J.) reported that its consulting chemists had found a more economical way to produce tetraethyl lead by reacting lead-sodium alloy with ethyl chloride under pressure. To gain the maximum working advantage from both discoveries—tetraethyl lead as an anti-knock agent and the ethyl chloride process of manufacture—General Motors and Standard agreed to form a jointly owned company, the Ethyl Gasoline Corp. (changed to Ethyl Corp., Apr. 9, 1942), to manufacture and market the compound. The new company was incorporated Aug. 18, 1924, in Delaware, with authorized stock of $5,000,000, divided into 50,000 shares of $100 par value. General Motors and Standard of New Jersey each subscribed to 7,500 shares of common stock at par, the only common stock issued. Ethyl was assigned the rights to the General Motors and Standard patents in the field of anti-knocks, and also acquired all assets of the GM Chemical Co., including the trade name "Ethyl," registered Aug. 5, 1924.

Kettering was Ethyl's first president and served until Apr. 21, 1925, when Earle W. Webb, formerly general attorney for General Motors Corp., succeeded him. Other officers were: Frank Howard, 1st vice-president; Midgley, 2d vice-president and general manager; Arch M. Maxwell, 3d vice-president and sales manager; Art Mittnacht, secretary-treasurer; and Chester O. Swain, general counsel. The original board consisted of Donaldson Brown, E. M. Clark, Alfred P. Sloan, Jr., Howard, John T. Smith, Kettering, Maxwell, W. C. Teagle, Midgley, and J. A. Moffett, Jr. Shortly after Webb became president, the board voted to withdraw "Ethyl" gasoline from public sale until an investigation could be made of charges that it was detrimental to public health and safety. The U. S. Surgeon General's office was asked to appoint an impartial committee to consider the health angles of tetraethyl lead at all stages of its manufacture, distribution, and use. The committee conducted its study over a seven-month period, reporting in Jan. 1926 that the addition of 3 cc. or less of "Ethyl" anti-knock compound to a gallon of gasoline could not be considered a peril to public health and safety, provided certain prescribed safety measures were met. Ethyl kept its product off the market for an additional five months, during which time it put into effect all safety measures recommended by the committee.

On June 1, 1926, when "Ethyl" again was offered to the public, its sales area consisted of 28 states. By 1927 it could be purchased in any section of the country and was steadily increasing in demand so that between 1929-35 Ethyl had to add four new manufacturing units, plus auxiliary buildings, at Deepwater. Until 1933, "Ethyl" anti-knock compound was added only to the premium gasoline of customer oil companies. That year it was made available for regular grade or "house brand" fuels. During the depression, oil companies hesitated to invest in new refinery

equipment to improve their "house brand," and sales of premium gasoline were declining. However, with tetraethyl lead added to their "house brand" gasoline, oil companies were able to offer motorists more automotive power and performance at the regular price.

Although the yearly production of tetraethyl lead now had exceeded 150,000,000 lb., this was insufficient to meet the demands for high-octane fuels during the recent war. By expanding facilities at its new plant in Baton Rouge, and by readjusting some of the manufacturing processes, Ethyl increased its wartime capacity output 43%. Earlier construction had raised the Baton Rouge capacity in 1941 to 75% above that of Sept. 1, 1939, when war broke out in Europe.

When "Ethyl" gasoline was first offered to the motorist, the Dow Chemical Co. was producing virtually the nation's entire output of bromine from Michigan salt brine. Yet this represented only a fraction of the amount of bromine Ethyl estimated it would need for future production of anti-knock compounds containing ethylene dibromide. Sea water had never been worked for a chemical on a commercial basis, but laboratory tests convinced Midgley, Dr. Edgar, James P. Andrew, and others that such a step was practical. As a result, Ethyl purchased a Great Lakes cargo ship, converted her into a floating chemical factory, and sent her to sea. The *S.S. Ethyl* sailed the waters off the Carolinas for a week in late April and early May 1925, pumping thousands upon thousands tons of water from the ocean and extracting some of the 67 parts of bromine that are found in every 1,000,000 parts of sea water. Although the *S.S. Ethyl* never sailed again as a sea-going bromine extraction laboratory, it had proved at the source that bromine could be separated from the ocean on a commercial basis.

In the early 1930's, Ethyl and Dow formed the Ethyl-Dow Chemical Co., which has since built two sea water-bromine extraction plants. One of the plants, which went into operation in Jan. 1934, at Kure Beach, N. C., was placed in stand-by status at the end of World War II. The other, built during the war at Freeport, Tex., produces the ethylene dibromide, and ships it by tankcar to the Ethyl manufacturing plant at Baton Rouge.

The Baton Rouge plant for the manufacture of anti-knock compounds is the largest in the world and the only completely integrated installation of its kind. It was started in the fall of 1936 on a 200-acre tract of land. In almost continuous expansion ever since construction began, the plant represents an investment of nearly $50,000,000. Additional large sums have been appropriated for postwar expansion. During World War II, approximately 85% of the plant's output was used directly in the war effort, largely in the production of 100-octane and other aviation fuels and for superior gasoline to power tanks, trucks, PT boats, and other machines of war. For "meritorious service on the production front," the plant won two Army-Navy "E" awards. In the early stages of the synthetic rubber program, part of the ethyl chloride facilities were used to test the workability of a process for manufacturing butadiene, while a number of large plants designed to make Buna rubber were under construction. One of the units was converted for ethylene dichloride, which the Rubber Reserve Corp. used for the manufacture of Thiokol. In recognition of Ethyl's "meritorious contribution to the design, construction, and operation of the American synthetic rubber industry," Ethyl Corp. received a Chemical Engineering Achievement award from *Chemical & Metallurgical Engineering*, Dec. 8, 1943.

Ethyl Corp. has always recognized the importance of research to continued automotive progress. Its philosophy is based upon the recognition of the interdependence of fuels and engines, and to this end it makes available to the automotive and petroleum industries a vast fund of basic information relating to high

compression and supercharging of all types of automotive engines, and to their fuel requirements. Cooperative research with farm machinery manufacturers has resulted in the development of the modern gasoline-powered tractor; that with manufacturers of valves and associated engine parts, in greatly increased engine durability. Continuing studies on ceramics, gap geometry, and electrode materials have aided manufacturers of aircraft and automotive spark plugs in bettering their products.

For the past 10 years Ethyl Corp. has maintained research fellowships at Brown, Michigan, Oklahoma, Tulsa, and Wayne Universities. Postwar the number of fellowships has been increased and Ethyl is investigating the feasibility of granting research fellowships to outstanding young college teachers, as well as graduate students.

The first Ethyl research laboratory was established in a converted garage in Yonkers, N. Y., in Jan. 1926. Today, the Corporation maintains laboratories in several key cities, the main laboratories being in Detroit. The bulk of the road testing of fuels and engines is conducted in a smaller laboratory at San Bernardino, Calif. Here one of five gasoline-testing laboratories is located, the others being at Baton Rouge, Yonkers, Kansas City, and Tulsa. These laboratories sample gasoline obtained from oil refineries, service stations, and bulk plants as to the amount of anti-knock compound needed to make "Ethyl" gasoline that will conform to the standards established under Ethyl license agreements with customer oil companies. The samples from service stations and bulk plants provide a spot-check against deterioration or contamination of the gasoline after it has left the refinery.

"Ethyl" anti-knock compound is sold to approximately 240 major oil refiners, who are licensed by Ethyl to blend the product with their own gasoline at their own refineries and sell the finished product through many thousands of jobbers and dealers. While Ethyl Corp. does not sell its compound directly to the motorist-consumer, it maintains a full-scale Sales Department with offices in important cities. Ethyl "salesmen" are tractor, fleet, and safety engineers. They cooperate closely with Ethyl's customer oil companies, aiding them to offer leaded gasoline at its full advantage to urban, rural, fleet, aviation, and marine users.

For the first score years of its existence, Ethyl manufactured only anti-knock compounds, but in 1943 it started to manufacture salt cake and in 1944 it entered the direct-to-consumer field with "Ethyl" Cleaner, a synthetic detergent having a petroleum base. Ethyl Specialties Corp., a wholly owned subsidiary, was incorporated Jan. 2, 1946, to market this packaged product.

On Aug. 9, 1947, Edward L. Shea was elected president, succeeding Earle W. Webb who became chairman of the board until his retirement on Mar. 1, 1948. Present Ethyl officers in addition to Shea are the following vice-presidents: John H. Schaefer, Harry W. Kaley, Stanley T. Crossland (also treasurer), and Dr. Graham Edgar. Richard M. Page is secretary. On the board are Frank W. Abrams, Albert Bradley, W. R. Carlisle, Crossland, F. G. Donner, Robert T. Haslam, Frank A. Howard, Kaley, C. F. Kettering, C. L. McCuen, Schaefer, Shea, and Webb.

FANSTEEL METALLURGICAL CORPORATION had its inception in the early 1900's when Carl A. Pfanstiehl invented an induction coil, unique in that the secondary circuit consisted of "pancake" windings so arranged that it was almost impossible to burn them out. Pfanstiehl made these coils in his home and sold them to medical men in the Chicago area for their X-ray apparatus. His friend James M. Troxel visualized the use of the Pfanstiehl coil for ignition in the one- and two-cylinder automobiles which were beginning to appear on the streets. So with Troxel's savings and borrowed capital aggregating $2,500, the Pfanstiehl

Electrical Laboratory was established in 1907 in a small rented building in North Chicago, Ill. Pfanstiehl, unassisted, made the coils in a back room while Troxel handled business details and sales. Before the year had passed, the Company was incorporated in Illinois and had begun to outgrow its small quarters.

Before World War I, magnetos, master vibrators, starter coils, and transformer coils were added, and the name Fansteel was first used on a household electric iron, discontinued in 1915. At this time a decision was made which eventually changed the entire course of the business. The electrical contacts for these automotive parts were made of platinum, a costly item, so a substitute was sought. Tungsten showed promising possibilities, but how to fabricate this hard, stubborn metal into precisely shaped contact discs and how to fasten these discs securely to support members posed hard problems. Pfanstiehl developed a method of slicing discs from tungsten rods with thin abrasive wheels under water and practical methods of brazing these tungsten discs to support members in hydrogen atmosphere furnaces were worked out. Ignition manufacturers turned to Pfanstiehl for tungsten contact parts, and the tungsten business outgrew the coil enterprise. Manufacture of coils and magnetos was finally discontinued in 1921.

Purchased tungsten rod presented some difficulties, and in 1914 Dr. Clarence W. Balke, who had done substantial work on rare metals and earths and supplied some pure tungsten powder which General Electric used in the development of ductile tungsten filament wire, became consultant to assist Pfanstiehl in developing tungsten metal satisfactory for use in electrical contact points. Two years later he resigned his professorship at the University of Illinois and June 1, 1916, became Pfanstiehl director of research and development. May 1915 Pfanstiehl wrote to Balke, "Demand for tungsten products has increased so rapidly during the last month that we are compelled to increase our capacity over 100% more than we had figured on. We will soon be turning out from eight to ten kilograms a day." Oct. 1945, Fansteel and its wholly owned subsidiary, Tantalum Defense Corp., produced an average of 632 kilograms of tungsten per day. The Company grew and branched out into many fields, some of which proved unprofitable.

Apr. 1916, uranium metal was made in the laboratory. Almost 30 years were to pass before uranium became of world importance, so, as far as Pfanstiehl was concerned, its production never got beyond the laboratory stage. With molybdenum and tantalum, however, the story was different. DeForest had invented the triode audion tube, which, with incandescent lamps, offered a market for molybdenum grid wire, hooks, and support members. So, by 1915, Pfanstiehl was producing molybdenum from purchased molybdic anhydride.

Balke in 1905 had determined the atomic weights of tantalum and columbium, and as early as 1915, in the University laboratory and at Pfanstiehl, he was trying to isolate the former metal. Von Bolton had made some small bits of tantalum in 1903 and some 200,000,000 tantalum lamps were made in Europe and America before tantalum filaments were replaced by tungsten. When the war in 1914 put an end to German production, Pfanstiehl and Balke redoubled their efforts to make the metal. But several years were to pass before any tantalum products were sold. The Company was incorporated in New York as Pfanstiehl Co., and July 5, 1918, the name was changed to Fansteel Products Co.

During World War I, Fansteel's facilities, devoted almost entirely to production for the Armed Forces, included tungsten electrical contacts, molybdenum firing pins for Navy guns, keyway cutters, hollow stem mercury-cooled valves for aircraft engines, and mischmetall, a mixture of cerium earths in iron, which was used in tracer bullets. In 1919 Pfanstiehl left to establish Pfanstiehl Chemical Co., manufacturing rare chemicals and drugs, and Balke again turned his attention to

tantalum. Knowing the metal's almost complete immunity to chemical attack, he visualized large, ductile sheets fabricated into acid-proof chemical equipment. The largest sheet made up to that time was not much more than one square inch. By 1922 he had the first tantalum "ingot," one-eighth inch square by two inches long, but the metal was pure, ductile, and malleable. No way was known to weld, harden, or anneal it. Dr. Balke and his associates thought that tantalum might work well as electrodes in chlorine cells, but the positive electrode formed a stable oxide film which blocked the current. Turning defeat into victory, Dr. Edgar W. Engle conceived the idea of a rectifier cell, containing a tantalum electrode and a lead electrode. In such a cell, current flows from the lead to the tantalum, but not in the opposite direction. Within a few months after Dr. Engle's discovery in 1923, the Fansteel plant was turning out Balkite tantalum rectifiers and "B" power units by the million. Sales and profits pyramided. Nation-wide distributor outlets were set up and elaborate promotion campaigns put into force. Oct. 23, 1926, Fansteel presented Walter Damrosch and the N. Y. Symphony Orchestra over 13 radio stations, the first sponsored network broadcast.

The alternating current tube appeared in 1927, and Fansteel's profitable market was wiped out. A heavy bond issue was floated to set up a radio manufacturing subsidiary which never earned a nickel. In 1923 tantalum diaphragms were made for introducing accurate amounts of chlorine in municipal water supplies and the first of these valves was installed by Chicago. An adaptation of the Balkite tantalum rectifiers was designed to charge railway signal batteries at the signal locations, for telegraph service, for telephone switchboard batteries, and still another for fire and burglar alarm systems. Production of tungsten contact points and molybdenum wire and sheet for radio tubes went on. These enterprises kept the Company intact after the market for radio battery chargers disappeared.

Almost any gas combines with tantalum at temperatures above dull red heat, which makes production of the metal extremely difficult. A piece of tantalum in a radio tube in a position where it would be heated and absorb the stray gases left in the tube after pumping, or the gases released by other metals in the tube, and thus maintain the high vacuum necessary for good performance, was an idea that looked good, and in 1923 a patent was applied for. Experiments proved that to use this beneficial property, special tubes would have to be designed. The factories showed little interest, but one tube engineer did: Frederick L. Hunter, then connected with the DeForest enterprises. In 1928 he joined the Fansteel research staff and designed and built several hundred sample tubes. These were submitted to tube manufacturers in the hope of inducing them to use tantalum. The idea took hold quickly in Europe, especially in France and Germany, but it grew more slowly in the United States. Nevertheless two young engineers on the Pacific Coast became keenly interested—W. H. Eitel and J. A. McCullough of Heintz & Kaufman, Ltd., San Francisco, who were in the business of making and servicing marine radio equipment, including tubes. Tantalum was adopted by these engineers as a material of tube construction, and the design foundations were laid for types of short-wave and ultra-high frequency tubes which became so important in World War II for radar equipment.

In the meantime, fundamental research in tantalum went on under Dr. Balke, Dr. Miner M. Austin, Roy A. Haskell, Howard W. Philip, Hunter, and others. Little was known of the properties of the metal, and next to nothing of fabricating techniques. Commercial uses of the metal, excepting simple shapes and forms, had to wait until methods for machining, deep drawing, welding, hardening, and annealing could be developed. Welding alone presented a problem which was not solved until 1931. Annealing techniques were not perfected until 1935. Equipment

was developed to compact and sinter larger pieces. Applications were developed for the chemical industry. Tantalum spinnerettes for making rayon yarns came into being, and while not widely adopted in the United States where styles change frequently, they were sold extensively throughout Europe and Japan.

More rare metals were investigated. Metallic cesium and rubidium and their pure compounds were made for use in photoelectric cells, and in 1929 the first piece of pure columbium metal was displayed by Fansteel at the Chemical Exposition. Production of tungsten electrical contacts went on in constantly increasing quantities. According to Bureau of Mines figures, 45 tons of pure tungsten were produced for electrical contacts in 1929, compared with five tons for lamp filaments, and most of this metal was made by Fansteel.

Burdened by the debts of the abortive adio receiver enterprise, Fansteel was almost overcome by the Great Depression. Robert J. Aitchison, Chicago accountant who had audited the Fansteel books since 1914, saved the Company. He was selected by the bank which held most of the Fansteel debentures in 1932 and directed either to liquidate the Company or put it on a substantial footing. Seven years later, he made an unsecured loan at the same bank to retire the last of the debentures. Assuming the duties of vice-president and general manager, Aitchison saw what the directors had failed to perceive—that Fansteel's talents and profits were in the field of the rare refractory metals and not in the competitive field of mass production of consumer goods. Fansteel began to hire more research workers and engineers developing easier ways to make more metal and new techniques and uses. Savings in the cost of making tungsten electrical contacts were split with customers, which in a small way helped the crippled automotive industry back on its feet.

In 1928 tungsten carbide tools imported from Germany made their appearance. Technically, the making of tungsten carbide does not differ greatly from that of metallic tungsten, and development work started in the Fansteel laboratory on various carbides and other hard metal compounds. Working on this project, Dr. Balke made the fundamental discovery that tantalum carbide, used either alone or in conjunction with tungsten carbide, reduced the coefficient of friction at the cutting tool edge, which overcomes the destructive effect of chip wear and "cratering" caused by a continuous hot chip passing over the top of a tool. This discovery virtually doubled the utility of cemented carbide tools and extended the use of cemented carbide in wire and tube-drawing dies. In 1930 the first Fansteel carbide tools and dies were marketed under the trade name Ramet, a contraction of "rare metals." The tantalum carbide discovery was made available to other American concerns starting in the carbide tool industry. Progress was slow and it was speedily found that carbide tools would have to be sold and serviced by experienced tool men. High-speed-tool steelmakers had become aware of cemented carbide, and Vanadium-Alloys Steel Co. purchased carbide blanks from Fansteel and mounted them into cutting tools sold under the name Vascoloy. To combine Fansteel's metallurgical and manufacturing facilities with Vanadium's tool-engineering experience and sales outlets, the two companies joined forces and on Aug. 16, 1933, established the Vascoloy-Ramet Corp., two-thirds owned by Fansteel, one-third by Vanadium, to manufacture cutting tools, drawing dies, blanks, and wear-resisting parts from essential carbide powders supplied by Fansteel.

The period 1934-40 was a "golden age" of research, extension of plant facilities, and increase of sales outlets. Dr. Frank H. Driggs came to Fansteel to relieve Dr. Balke in directing the growing laboratory staff, and by 1938 had become vice-president in charge of technical development. Other important members were added to the staff: Claire C. Balke, son of Dr. Balke, authority on powder metal-

lurgy; Dr. John D. Kleis, research physicist in electrical contacts; Dr. Rae Winchester, chemical engineer skilled in plant-scale equipment for purifying refractory metals; and Harry W. Highriter, expert in refractory metal carbides. Aug. 28, 1935, the Company's name was changed to Fansteel Metallurgical Corp. as being more truly descriptive.

In 1932 a major chemical producer became interested in a tantalum heat exchanger capable of producing 50 tons of purified ammonium chloride per day. Many attempts were made to design a satisfactory unit, but to withstand the high external pressures, seamless tubing was the only practical solution. Tantalum could not be made into seamless tubing until some satisfactory method of annealing was developed and the heat exchanger design required 174 seamless tantalum tubes, each five feet long. The annealing technique was rushed to completion under F. L. Hunter, while Howard W. Philip developed mechanical methods for drawing the tubing. The heat exchange built proving highly successful, Fansteel then began in earnest to cultivate the chemical equipment field.

As the demand for tantalum grew, ore supplies became a problem. The only source was a mine in the desolate Pilbarra district of Western Australia, which operated a few months of the year after the brief rainy season. Ore had to be hauled, first on camels and later by truck, 450 miles to the nearest seaport, whence it was shipped halfway around the world to North Chicago. Deliveries were uncertain with months of delay. The Black Hills Tin Co. owned a mining property at Tinton, S. D., which contained an appreciable deposit of tantalite. This property was leased by Fansteel Mining Corp., a wholly owned subsidiary established for this purpose. The concentrating mill was rehabilitated and mining operations were started in 1937 and continued for two years. This was not a profitable venture, but it taught Fansteel to process low-grade ores economically and led to prospecting for tantalite in many parts of the world. Prospectors and mining engineers were supplied with samples and information to identify this unusual ore. A number of deposits were located, and one in particular, the Geomines deposit in the Belgian Congo, became a valuable source of supply. This early prospecting work became really appreciated during World War II when tantalite became a critical strategic mineral and ores were delivered by air to keep tantalum production going.

Experiments indicated that the inclusion of tantalum or columbium carbide in a hard-cast alloy of the tungsten-chromium-cobalt group produced an alloy that would not only provide a sales outlet for the carbide constituents, but also a by-product market for tungsten metal. The first alloy, called Tantaloy, was marketed in 1937 in rods, which could be applied by acetylene torch to steel bars, sharpened, and put to work as heavy cutting tools. Tools made in this manner performed beautifully in heavy hogging cuts where one-fourth to one-half inch of metal was removed, but they were not as good as steel tools on medium or light cuts. Two years later the successful alloy was introduced under the trade name Tantung in the form of solid square and rectangular tool bits, tipped tools, and wear-resisting parts. Tantung tools could machine anything that could be machined at all at approximately double the speed possible with high-speed steel tools. They required none of the careful engineering or special grinding techniques of carbide tools. Many of them were sold in cast form to tool manufacturers who finished and distributed the products.

The Balkite tantalum rectifier for converting alternating current into direct current is very efficient, but requires periodic addition of water, and because of the danger of spilling electrolyte is not portable. During the 1920's experiments were going on with so-called metallic or dry-plate rectifiers and Fansteel in 1928 obtained a patent on a rectifier of this type, but never produced it commercially. In

1929 the copper oxide rectifier was introduced in the United States as a competitor. Meanwhile the selenium rectifier was being developed in Europe and in the late thirties manufacture began here by an affiliate of International Telephone & Telegraph Corp. Late in 1939 Fansteel made an arrangement with I. T. & T. and introduced to the railway signal field a line of selenium rectifier units using rectifier stacks made by I. T. & T. This development was extended to railway telegraph power units, and many types of rectifiers and battery chargers for utility, industrial, and communications service. At the same time, Fansteel became an agent for I. T. & T. in selling selenium rectifier stacks to electrical manufacturers who incorporated them into their own products. All this work built up a reservoir of engineering experience which earned Fansteel an enviable reputation in the rectifier field and proved to be of immense value during World War II.

Late in 1937 the first tantalum hydrochloric absorption plant was installed in the St. Louis plant of Monsanto Chemical Co. Within five years more than 70 Fansteel acid plants had been installed in the United States, Canada, South America, Europe, Australia, and India. By 1942 nearly 80% of the nation's commercial hydrochloric acid was being produced in Fansteel equipment. The use of tantalum in other chemical equipment grew. A plant for the purification of bromine was developed and several units sold to producers of this extremely corrosive element. A complete plant for production of anhydrous hydrogen chloride was also designed and several units sold. In 1940 the first plant in the United States, and the then-largest in the world, for making phenol by the Raschig process, was put into operation by Durez Plastics & Chemicals, Inc. Thirty-two large tantalum bayonet heaters were installed to evaporate mixtures of hydrochloric acid and chlorinated benzenes. Thus tantalum earned recognition as a material of construction in the chemical process industries.

Another important development started in 1937 when Dr. John C. Burch of the medical faculty of Vanderbilt University and Dr. Gerald Burke of Vancouver, B. C., both used tantalum wire in surgical repairs, first on animals then on humans, and found the metal not only inert to body chemistry, but apparently acceptable in the same manner as living tissue. Fansteel inaugurated a program of promotion and research in medical centers, notably the Montreal Neurological Institute, the Cleveland Clinic, and the Medical School of Northwestern University. All reports indicated the same general results: tantalum implants could be left permanently in the body with no apparent ill effects due to corrosion of the metal or deterioration of surrounding tissue. The metal was speedily adopted for two important operations: the repair of skull injuries and severed nerves. Before the war ended, more than 5,000 successful skull operations had been performed. Approximately 10% of the battle casualties involved repairs to injured or severed peripheral nerves. The Spurling technique of joining the nerve ends with fine tantalum wire and wrapping the anastomosis in a sheet of tantalum foil was adopted by Army and Navy surgeons generally, and thousands of such repairs were made. Plastic surgeons made artificial jawbones of tantalum, also frameworks for missing ears and noses. Tantalum wire for sutures was used by the mile.

Four months before Pearl Harbor, blueprints for a $5,000,000 tantalum plant were laid before the authorities in Washington. These plans contemplated a long, hard war, and a larger radar communication and electronic tube program than the actual program turned out to be. Government approval was obtained, and in Jan. 1942, the Defense Plant Corp. authorized construction of the plant to be operated under lease by Tantalum Defense Corp., a wholly owned Fansteel subsidiary. Ground was broken in February, and the first shipment was made in September. By the end of the year the plant was producing tantalum sheet, wire, and fabricated

electronic tube parts far beyond its planned capacity. In the meantime, the facilities of the old plant were being used around the clock and the walls bulged with added equipment and personnel. In 1943 three additional buildings were built and were in production by Mar. 1944.

During 1943 Fansteel technical counsel was sought by the Manhattan Engineering District, and while the details cannot now be told, Fansteel and Vascoloy-Ramet Corp. were two of the 116 industries, universities, and institutions upon whom the award for Chemical Engineering Achievement was conferred "in recognition of unique meritorious contribution to the atomic bomb project." The Army-Navy "E" was conferred four times upon the employees of Fansteel Metallurgical Corp. and Tantalum Defense Corp., and once upon those of Vascoloy-Ramet.

Despite the rigid wage and price controls of the war years, costs of operating industrial establishments increased substantially, and Fansteel's costs probably increased more than the average because of the additional supervision required to oversee inexperienced plant personnel and the constant risk of spoiling valuable metals. Notwithstanding, Fansteel in 1944 made 27-31% reductions in prices of certain widely used sizes of molybdenum and tungsten wire and rod.

At the end of war, on the asset side Fansteel had a smooth-working organization. Hundreds of industries had learned the benefits of its rare metal products and an imposing list of customers and potential customers seemed good prospects for postwar growth. In scientific circles Fansteel's accomplishments had earned recognition and the Company was in a strong financial position, with all preferred stock retired and no funded debt. But there was an outgrown, worn-out plant, excepting the selenium rectifier plant and an addition to the electrical-contact building constructed with Company funds during the war. There was the burden of operating and maintaining the government-owned tantalum plant, strikes in customers' and suppliers' plants which curtailed orders and caused shortages, and rising labor costs.

As in 1932, Fansteel met these problems with an expansion program. A new products committee, headed by top executives, was established to study every possibility of new products incorporating Fansteel metals, or something which could be made with existing equipment and technical knowledge and sold through existing outlets. A major obstacle was overcome Apr. 18, 1947, when the government-owned tantalum plant was purchased by Tantalum Defense Corp. under a contract whereby the Corporation is committed to maintain the productive capacity available in case of emergency.

Experiment and facilities do not make the Fansteel organization unique. Fansteel's most important asset is its skill, experience, and courage of a loyal, closely-knit technical organization which devotes itself to the solution of intricate problems in the refractory rare metals, problems which lie at the very frontiers of human knowledge.

FELTON CHEMICAL COMPANY was founded in 1922 by Dr. Joseph Felton and incorporated in New York in 1923. Born in Poland in 1891, and educated at the University of Birmingham, England, and the University of Breslau, Germany, Dr. Felton worked under Professor Semmler at Breslau, where he published several scientific papers on aromatic chemicals and essential oils. From 1914-19 he was studying and doing research under Professor Pictet of the University of Geneva, and Professor Dutoit at the University of Lausanne. In 1919 he came to the United States and became chief research chemist at Van Dyk & Co., in New Jersey. With his wife, Sophie Schulman, who graduated from Barnard College with a B.S. in chemistry and had been chemist for Colgate & Co., Dr. Felton estab-

lished a plant for the manufacture of aromatic chemicals at Taaffe Place, in Brooklyn, N. Y. One year prior, in 1922, he had opened a small consulting and manufacturing laboratory specializing in aromatic chemicals.

During its first years, Felton Chemical Co. produced many aromatic chemicals not as yet being manufactured in the United States. It made steady progress and in 1927 built a larger and modern building on Johnson Ave. in Brooklyn, for the manufacture of aromatic chemicals, terpeneless oils, and other natural concentrates, perfume oils, and imitation flavors. In 1933 Louis Gampert, formerly manager of the Buffalo plant of National Aniline & Chemical Co., joined the Company as vice-president and general sales manager.

The growth of the Company continued uninterruptedly. Research facilities were greatly expanded at the Brooklyn plant, new sales branches were opened in important cities, and manufacturing units were established in Los Angeles and Montreal. Sales activities are world-wide, with agents and representatives in numerous foreign countries. In 1939 an additional story was added to the Brooklyn plant, and in 1940 an adjoining property was purchased. With the occupation in 1948 of a new three-story structure, a building program initiated five years ago was brought to conclusion.

In 1941 Felton began manufacturing citrus oils in Florida under the Key Brand name. In 1946 an Essential Oil Department was added. The present officers and directors of the Company are Dr. Joseph Felton, president; Louis Gampert, vice-president; and Mrs. Sophie Felton, secretary-treasurer.

ALEX. C. FERGUSSON COMPANY was founded by a Scotchman, Alexander Cuthill Fergusson, Sr., who arrived in Philadelphia on the clipper ship *Tonowanda* from Liverpool, Nov. 1855, carrying with him a letter of recommendation from Robertson Bros. of Glasgow. Son of a prominent merchant, young Fergusson had apprenticed himself to a leading wholesale drug and chemical house in Glasgow some months before his departure for America.

Upon his arrival in Philadelphia Fergusson was immediately taken by his architect cousin living there, to the prominent drug and chemical concern of Dulles, Earle & Cope, which hired him. After the Civil War, two members of this firm having died, Fergusson continued the business as a brokerage under his own name. The third had already given him an unlimited power of attorney to conduct the business, which Fergusson did satisfactorily.

During the early years of its history, the Fergusson drug and chemical business embraced a very extensive list of products many of which the present generation would hardly recognize. As all of the alkalies at that time came from England, Fergusson early succeeded in getting sales agencies for some of the leading producers, with whom he became friendly. The most important items were caustic soda, soda ash, bleaching powder, bicarbonate of soda, sal soda, and chlorate of potash. The business prospered and large shipments of alkalies for the paper, glass, soap, textile, and other industries were coming in from England by every vessel. The brokerage business was not neglected, orders being taken for a long and varied list of chemicals, colors, pigments, dyestuff extracts, etc.

When the Solvay Co. was formed and began manufacturing soda ash, caustic soda, etc., in this country, the United Alkali Co. of Great Britain was formed, the first chemical trust representing the largest alkali producers abroad. Fergusson and his younger brother, John, whom he had brought over from Scotland, were greatly perturbed when United Alkali appointed New York selling agents. However, they continued to solicit the business for the brands they had been selling, and put orders through the New York agents in even increased volume. With the accept-

ances of their orders in hand, Fergusson, Sr., returned to Europe and showed the sales director of United Alkali that Fergusson Co. was still getting orders, and that the Philadelphia business of the New York agents was simply passing along Fergusson orders. By this maneuver different arrangements were made and Fergusson continued to sell the same brands as formerly.

As the manufacture of alkalies and allied products increased in the United States, Fergusson had to adapt itself to the changed conditions. It was selling imported Sicilian brimstone on the basis of 95% sulfur content. But when the Union Sulphur Co. was formed to develop and exploit the Frasch process for recovering sulfur from the beds of Louisiana, Fergusson, through his affiliations with the paper trade, made a selling agreement with the company and sold the first large contract for domestic sulfur. When the Hooker Electrochemical Co. was organized, its caustic soda and bleaching powder were placed with Fergusson, which successfully introduced these materials and still sells the Hooker brand.

During World War I, the Fergusson Co. set up a production laboratory on the site formerly occupied by Benjamin Franklin's Printing Shop, to develop an electrolytic process for the manufacture of potassium ferricyanide in great demand for blueprints. An output of several hundred pounds per day was maintained until after the Armistice. Wishing to continue to use these facilities, the Company, under the name of Fergusson Laboratories Division, began manufacturing potash soap base, liquid soaps, household insecticides, pine and coal-tar disinfectants. It developed a phenolic disinfectant with a phenol coefficient of 32.

The Laboratories were located at 17 S. Orianna St., in Philadelphia, the main offices of the Company being in the Drexel Bldg., next to Independence Hall. In 1925 additional property was purchased on Orianna St., to which the offices were moved. Construction of a modern manufacturing and storage building on Oregon Ave., Philadelphia, was begun in 1929 and removal to this building occurred May 1, 1930. In July 1934, owing to the encroachment of the manufacturing facilities of the Company, the offices were moved back to the Drexel Bldg., where they still remain. A year later the Company bought additional real estate adjoining its warehouse building, increasing the area by 300% and giving needed room for expansion of manufacturing facilities.

Alex. C. Fergusson, Jr., son of the founder and present head, entered the business, Feb. 1, 1892. Fifty years later he was tendered a testimonial dinner which was largely attended, not only by Company personnel, but friends and well wishers from distant points. Lyman S. Lloyd, first vice-president of the Company since its incorporation in 1931, has been with the business since May 1920. Elmer A. Talcott, secretary, joined in June 1919. The other officers of the Company as now organized are: John M. Applegarth, vice-president; Albert D. Frank, assistant to the president and sales manager; L. K. Siner, assistant secretary; V. J. Seckar, treasurer; and Edward Koch, plant manager and chief chemist.

With a force of a dozen or more salesmen operating from the main office and the Allentown, Pa., warehouse and office, Fergusson distributes chemicals manufactured by: Baker Castor Oil Co., Dow Chemical Co., Hooker Electrochemical Co., Philadelphia Quartz Co., Procter & Gamble Distributing Co., Rumford Chemical Works, Stauffer Chemical Co., and Phelps Dodge Refining Corp.

In the Fergusson Laboratories Division, Talcott, manager, are produced liquid and other potash-base soaps, shampoo, furniture polish, disinfectants and insecticides, pine jelly soap and other pine oil products, special detergents and cleaning compounds, all sold under the registered trade-mark AFCO. The Dairy Products Division, Applegarth, manager, produces detergents and other products exclusively for the dairy industry. The Metal Lubricants Division, W. A. Summers, manager,

manufactures drawing compounds, cutting oils, and coaters, added some years ago, and a superior strip-coat for stainless steel.

FIRESTONE TIRE & RUBBER COMPANY, one of the "big four" in the rubber industry today, was founded in Akron, O., in 1900, by Harvey S. Firestone, who was born on a farm in Columbiana County, O., Dec. 20, 1868. He helped his father in farm work, but success in trading in livestock convinced him that his future lay in commerce. After attending the Spencerian business college in Cleveland, he first kept books for a coal dealer; then sold patent medicines; and finally became salesman for the Columbus Buggy Co. While driving the first rubber-tired buggy in Detroit, he conceived the idea of manufacturing rubber tires for carriages, that was to found a vast industry. In 1896 he moved to Chicago and with two friends established the Firestone-Victor Rubber Co., of which he became president. Organized with a capital of $3,000, at the end of two years the company was able to buy out a competitor, the Imperial Rubber Co., and merge the Rubber Tire Wheel Co., thus becoming a leader in the buggy tire industry.

In 1899 Firestone disposed of this business and came to Akron, where with four associates, James Christy, Jr., James A. Swinehart, M. D. Buckman, and Dr. L. E. Sisler, he organized on Aug. 3, 1900, the present company with a capital of $20,000 in cash and $30,000 in patents and good will. The first tires were made for automobiles as well as carriages and involved a new principle in construction.

At first the Company's tires were made by another manufacturer and the business expanded so rapidly that in 1902 the capital was increased to $200,000. The same year an old foundry building was purchased in South Akron where the Company soon began to manufacture its own tires.

Firestone started out with "practical" rubber men who carried the rubber formulas for compounding in their heads. They knew the various types of wild rubbers and made mixtures by rule-of-thumb. Compounding was an "art," but in 1908 Harvey S. Firestone decided that it was time he had a chemist and a means of testing his tires. He hired a graduate of Buchtel College (now University of Akron) named John W. Thomas, who established the first chemical laboratory. In 1932 Thomas became president, and in 1938, chairman.

When the pneumatic tire for motor cars made its appearance, Firestone was quick to enter the new field. Refused permission to manufacture the early "clincher" tire controlled by a patent association, he developed a mechanically fastened straight-side pneumatic tire which was first sold in 1905. Henry Ford gave him an order for 2,000 tires and began taking delivery in 1906, but they ran into an unforeseen difficulty. The public balked at buying a car that could not be shod at home with the universally available clincher. Ford specified this tire for his car. Firestone, again refused a license by the clincher tire association, went ahead and made them for Ford. However, the monopoly was broken and the young company was free to make its product unharassed.

When Firestone started making pneumatic tires in 1905 the mixing formulas were simple: rubber, sulfur, lime or magnesia, zinc oxide, and a little lampblack. Around 1912, when the use of organic accelerators spread, the lime or magnesia was dropped. Near the end of World War I rubber researchers found that gas carbon black would improve immensely strength and resistance to wear of tires. After the war, the movement for better roads was bearing fruit and with better roads came faster cars. This called for better and better tires. Manufacturers were faced with the problem of tires deteriorating from age, as well as use. Oxygen in the air being deteriorating to rubber, antioxidants were developed which greatly improved the life of rubber products.

The Company had made additions to the original factory in 1904-6. In 1910 it bought 23 acres a mile away and next year occupied the new plant it built there. A second plant was soon started, designed for the exclusive production of small-size tires for popular cars, one of the first to apply the principles of straight-line production to tire manufacture. In the meantime the Company had developed a considerable business in rims, growing out of a demountable rim perfected by Firestone in 1907. The rim division took over the entire original tire factory and was incorporated as the Firestone Steel Products Co. In 1922 a new steel plant was built and a subsidiary factory later constructed at Wyandotte, Mich.

About 1910, Firestone Tire & Rubber Co. entered the reclaimed rubber field and during World War I constructed a factory as a subsidiary called the Xylos Rubber Co. Eight offices in the Far East were opened during this period and the Company built a $1,000,000 plant at Singapore in 1919, to prepare and ship rubber from Malaya, Sumatra, Java, and Borneo. Because of the Stevenson Rubber Restriction Act, enacted by Great Britain in 1921 to inflate the price of rubber, Firestone made a world survey to determine a suitable place to establish rubber plantations. It secured an option to lease 1,000,000 acres in the Republic of Liberia in 1924. From a force of 2,000 native laborers, the enterprise has grown to 35,000 workers and a plantation of 80,000 acres, most of it in production.

The Company constructed tire plants in Hamilton, Ont., in 1922; Brentford, near London, 1928; Los Angeles, 1928; Buenos Aires, 1931; Bilbao, Spain, 1933; Pratteln, Switzerland, 1935; Port Elizabeth, South Africa, 1936; Memphis, Tenn., 1937; Bombay, India, and Sao Paulo, Brazil, 1939. After World War II Firestone purchased tire plants which it had operated for the Government in Des Moines, Ia., and Pottstown, Pa., and acquired additional foreign factories in Viskafors, Sweden, and Christchurch, New Zealand.

Tire fabric of cotton, rayon, and nylon is made by Company-owned and operated factories at New Bedford, Mass., Gastonia, N. C., Bennettsville, S. C., and Woodstock, Ont., operating as Firestone Textile Co. Another subsidiary, Firestone Industrial Products Co., makes several hundred types of automotive parts, rubber and plastic, in Fall River, Mass., Paterson, N. J., Noblesville and New Castle, Ind., and Pottstown, Pa. Firestone entered the plastics field several years before World War II and a subsidiary, the Firestone Plastics Co., manufactures synthetic resins, films, and other plastic products.

In 1940 Firestone had a small commercial plant producing synthetic rubber. The first government-owned synthetic plant built and operated by Firestone went into production in Apr. 1942. Synthetic rubber plants operated by Firestone are in Lake Charles, La., Port Neches, Tex., and Akron. Chemists had to find new and improved accelerators and other ingredients for compounding synthetic rubber; the whole problem that they had taken 40 years to accomplish with natural rubber had to be done in a year or two. In making cords for synthetic tires for aircraft, first rayon and then nylon were used and found to be satisfactorily treated by the Firestone process of gum-dipping, a method specified by the War Department.

The research laboratory steadily expanded and in 1945 moved into a new $2,000,000 building given over exclusively to pure chemical and physical research. Other research activities are carried on in the Product Development Department and in other laboratories and include not only chemical compounding of raw materials, but engineering development in design and construction, such as electronic vulcanization, and improvement in the machines which makes these products.

The Company has sponsored research fellowships for many years in various universities, such as Princeton, University of Minnesota, Case School of Applied Science, Ohio State University, University of Akron, and has cooperative arrange-

ments with research foundations and institutes such as Mellon Institute, and government research laboratories.

In 1911 the capital and surplus of Firestone were increased to $4,478,000 and the sales reached $7,500,000. In 1938, the year of H. S. Firestone's death, the capital and surplus amounted to $107,362,244, with sales of $141,822,681. Sales reached $268,091,826 in 1941 and $638,447,166 in 1947.

The present officers of the Company are: Harvey S. Firestone, Jr., chairman; Lee R. Jackson, president; John J. Shea, vice- president, finance; James E. Trainer, vice-president, production; Harold D. Tompkins, vice-president, sales; Harvey H. Hollinger, treasurer; Joseph Thomas, secretary and general counsel; Claude A. Pauley, comptroller. The directors are: John W. Thomas, honorary chairman, Harvey S. Firestone, Jr., Jackson, Shea, Trainer, Hollinger, Russell A. Firestone, Leonard K. Firestone, Raymond C. Firestone, and Roger S. Firestone.

FISHER SCIENTIFIC COMPANY, one of America's leading designers, manufacturers, and distributors of instruments, apparatus, and chemicals for use in scientific laboratories, had its inception in 1902 in Pittsburgh. That year, Pittsburgh Testing Laboratories, which carried a modest stock of laboratory glassware, gradually became the source from which chemists of the surrounding territory purchased these items. Most of the supplies came from Eimer & Amend in New York, for whom Pittsburgh Testing Laboratories then acted as agent. A young graduate of the Western University of Pennsylvania, Chester G. Fisher, recognized the need for a full-fledged laboratory supply house in the area. He approached George H. Clapp of the Testing Laboratories, and after some negotiations, the Scientific Materials Co. was organized with Clapp as president and Lacy S. McKeever as secretary. The business was opened in the McNally Bldg., 711 Penn Ave.

Scientific Materials Co. continued as agent for Eimer & Amend for several years. Gradually more different items were stocked to meet the growing needs of laboratories in the tristate area. Clapp and McKeever withdrew from the Company because their entire time was required by Pittsburgh Testing Laboratories and Fisher purchased their interest, becoming president of the firm. Jan. 1926, the Company changed its name to the Fisher Scientific Co. to avoid confusion with other laboratory supply houses known by general names. A glassblowing department was added and an instrument shop assumed large proportions by the mid-thirties. A Development Laboratory was also set up and Fisher soon became a recognized leader in designing scientific instruments and laboratory apparatus.

By a somewhat ironic turn, the Company which had once been its agent purchased the entire capital stock of Eimer & Amend (in 1940) and then took over its laboratory supply business, as well as its facilities for manufacturing fine chemicals. The concern, pioneer of American laboratory supply houses, was moved to a modern building in the Greenwich Village district of New York where it plays an important role in serving chemists of the Eastern states.

Bernard G. Amend, founder of Eimer & Amend, was an assistant to Liebig when, in 1847, Eben N. Horsford, first professor of chemistry at Lawrence Scientific School, Harvard University, suggested that he come to Cambridge. Instead, Amend set up in 1851 a drug and laboratory glassware store at Third Ave. and 18th St. in N. Y. City. Into this little shop came such men as Hamilton Fish, Samuel J. Tilden, Peter Cooper, Abram S. Hewitt, Cyrus W. Field, Washington Irving, Charles A. Dana, and many others who became his friends. In 1856 Carl Eimer, Amend's old schoolmate, entered the firm and the company name was changed to Eimer & Amend. By 1874 a full line of assay, chemical, physical, and

medical laboratory equipment had been added to the original stocks of glassware and drugs. August E. Eimer, nephew of Carl Eimer, served as president for 14 years, retiring in 1925. It is interesting to note that on Aug. 1, 1874, Bernard Amend and a group of distinguished chemists, gathered at Priestley's grave at Northumberland, Pa., discussed the formation of a chemical society. With such men as Professors Chandler, Draper, Doremus, Morton, and Smith, Amend took an active part in the organization of the American Chemical Society in 1876.

Fisher Scientific Co. and Eimer & Amend have been intimately associated with many major developments in chemistry and science in America. Thomas A. Edison, Dr. E. R. Squibb, and Henry Ford frequently visited the Eimer & Amend showroom to purchase laboratory supplies. Edison found there the hundreds of materials he used in research that led to the incandescent lamp. Upon the discovery of X-rays, Eimer & Amend immediately imported a Roentgen tube for Dr. Chandler and its glassblowing shops manufactured similar tubes in small lots. These were the first X-ray tubes made in America.

Eimer & Amend's pharmacy is now not only one of the oldest, but also the leading prescription laboratory in the New York area. It has filled more prescriptions—over 8,000,000—than any other pharmacy in America. It was moved in 1941 to a separate building at 49 E. 34th St., where it now operates as an exclusive prescription laboratory under the name Eimer & Amend Apothecary. In 1943 a separate Eimer & Amend Chemical Division was established at Edgewater, N. J . The Company's chemical catalog lists nearly 7,000 different reagent chemicals, including about 500 "E. & A. Tested Purity Reagents." This line of C.P. reagents was the first in America to be analyzed and to bear labels stating the exact amount of impurities.

The Fisher plant at Pittsburgh—doubled in size during 1947—provides manufacturing shops, specialized development laboratories, offices, and modernized facilities to handle stocks of more than 9,000 different apparatus items. A Canadian branch was set up in Montreal, 1925, and at the outset of World War II, a separate warehouse and office were established in St. Louis to serve chemists in the Central States area. More than 1,100 specialized personnel were employed in 1947 in the four Fisher distribution centers.

In the early 1930's Fisher began developing and introducing new and improved instruments not only in industrial control but also in the field of pure research. Some more notable contributions include an electrometric titration device, a unitized system for gas analysis, a basic instrument for the dropping electrode system of analysis, and an electromagnetic instrument for rapid determinations of carbon in steel. The Company also devised an electrophotometer employing photoelectric cells which revolutionized and extended the field of colorimetric analysis and made available a new tool for investigating the applications of supersonics.

With its growth and in addition to providing better tools, Fisher Scientific has made numerous, valuable contributions to science in many different ways. It publishes and distributes free a magazine, *The Laboratory,* devoted to announcements of new developments in laboratory apparatus and techniques. It maintains technical service departments to advise scientists regarding procedures, and its staff has made numerous contributions to scientific journals. Beginning in 1948, the Company, in cooperation with the American Chemical Society, presents an annual $1,000 award for outstanding achievement in analytical chemistry.

Associated with Chester G. Fisher in management are his sons, Aiken W., Benjamin R., and James A. Fisher, and serving in executive capacities are Howard W. Koch, vice-president, Eimer & Amend; B. G. Hoerr, vice-president,

St. Louis branch; and John P. Melhorn, president, Fisher Scientific Co., Ltd., of Canada.

FOOTE MINERAL COMPANY evolved from a display of minerals at the Centennial Exposition in Philadelphia, 1876, by a Fellow of the American Association for the Advancement of Science and of the American Geological Society, Dr. A. E. Foote. He had studied at Cambridge and in Berlin; taught at the University of Michigan and Iowa State. The display took first prize for scientific interest and beauty of form and color, stimulating national attention, and Foote was deluged with requests for good mineral specimens to complete collections in colleges and other institutions. His reputation grew, and before the end of 1876, he had given up teaching for the business of acquiring mineral specimens. By 1889 he had collected 700,000 specimens from every corner of the globe. The Academy of Natural Sciences and the American Museum of Natural History in New York made Foote a life member. A mineral, footeite, was named after him and he was exchanging letters with 21,500 persons in every part of the world.

In 1900 Warren Foote, son of Dr. Foote, became president of the "Collectors of Mineral Specimens and Meteorite Chasers," and true to old tradition, exhibited colombotantalite from South Dakota at the Paris Exposition. A representative of Siemens & Halske of Charlottenburg, Germany, interested in replacing the Edison carbon filament with tantalum, saw the specimen and decided Foote must know where to get tantalum ores. The order placed with Foote resulted in a trip to the alluvial deposits of tantalum in Australia and the start of commercial enterprise. It is not so strange then that the Company decided to become the purveyor of rarities to industry.

July 26, 1916, the Foote Mineral Co. was incorporated as manufacturers of mineral products and specialists in unusual ores, with Warren Foote as president, H. Conrad Meyer, vice-president, and I. M. Mackey, secretary. Foote continued as president until his death in 1936, at which time Meyer became president and still continues in this capacity. Gordon H. Chambers joined the Company in 1928, starting in the Sales Department, later becoming secretary and sales manager, and now vice-president. Ernest G. Enck was first employed as chemist in 1926, later becoming chemical director and since 1942, secretary. L. G. Bliss, director and sales manager, first joined the Company in 1933 in the Research Department, and has been a director since 1942. F. B. Shay, mining engineer, came to Foote in 1940 in charge of the mineral processing plant, has been a director since 1942, and is now production manager. The newest Foote director, 1947, is R. J. Lewis of New York.

In 1913 Foote Mineral Co. began an extensive educational campaign throughout America with a view to introducing zirconium to the metallurgical and chemical industries. Two years later, Meyer visited the zirconia mines and deposits of Brazil and reported their commercial possibilities in American trade journals. His experimental work resulted in the introduction of zirconia refractories for high-temperature applications and uses where high resistance to corrosive slags, fusion mixtures, and gases is required. At the Chemical Exposition, Sept. 1920, Foote demonstrated the refractoriness of zirconia products, utilizing a 20 kw. Ajaz-Northrup high-frequency induction furnace. It is said, "a specimen of pure molybdenum metal was completely melted within the zirkite crucible at a temperature of 2,550° C. in less than 26 minutes." Concurrently with the development of refractory uses of zirconia occurred the development of a procedure to manufacture zirconium dioxide and hydroxide as an opacifier in acidproof enamels and glazes for cast-iron and steel vessels. Its resistance to chemical action made it superior

to tin oxide, heretofore the only reliable opacifying agent. The shortage of tin in the First World War enabled Foote to introduce and produce commercially the first zirconium opacifiers in the United States.

During the same period, Foote participated in the earliest American production of tungstic and tellurium oxides and selenous acid, and in some of the earliest investigations of lithium and strontium chemicals. The Company also supplied large quantities of crude and processed minerals and ores. It made the first importation of stronium ores to America for the then-youthful strontium industry. In 1927 commercial production of yttrium chemicals was undertaken, as well as the introduction of cesium salts, the latter playing an important part in the development of radio and photoelectric tubes.

With continued faith in zirconium in industry, Foote Mineral Co. introduced in 1929 the first commercial production of zirconium metal powder in the United States. This was first used in smokeless flashlight powder. Under G. H. Chambers, the Research Department developed important applications for the metal in pyrotechnics and ammunition primers. Its great affinity for gases played a most important role in the design and production of many important radio tubes used in World War II. Another zirconium "first" was the commercial American production of ductile zirconium metal in 1939, in the form of wire, sheet, and rod. The ductile metal displays unusual properties for chemical corrosion resistance and dropwise condensation.

In 1933 Foote Mineral Co. introduced "commercial" grades of lithium compounds in addition to the "N.F." grades. From modest outputs of the carbonate for glass and the chloride for air conditioning developed one of Foote's most important chemical operations. Through the efforts of Foote's research and lithium production, lithium chloride and fluoride were advanced in the light-metal welding and brazing industry. During World War II, the use of special high-temperature and low-temperature greases, particularly valuable in aeronautics, were the result of Foote's research and introduction of suitable grades of lithium stearate. In 1937 Foote began production of strontium carbonate, oxalate, hydroxide, chloride, and stearate, a unit which developed into the largest plant for these salts in the world. These compounds find their way into pyrotechnics and the oil, alkali, medicinal, and ceramic industries.

Prior to 1941 chemical production at Foote's was conducted in two plants in Philadelphia. For expansion, a location for both chemical and mineral processing was found in the beautiful Chester Valley near Philadelphia. At present (1947) there are over 30 buildings—some 80 acres—complete with rail service from two lines, power and water, laboratories, and lunch room for employees.

With its intimate knowledge of mineral sources and technically trained personnel, Foote has become in the past 30 years recognized headquarters for both common and uncommon ores, minerals, and chemicals. Its confidence in the future of certain so-called "rare" elements has led to processes and established manufacturing facilities for their production. Foote has taken minerals out of the museum and put them to work in the plant to serve industry and keep "a step ahead in industrial ores and chemicals."

FREEPORT SULPHUR COMPANY derives its name from Freeport, one of the oldest names in American sulfur mining. Originally chartered in Texas, July 12, 1912, it has supplied the nation with brimstone for a longer period than any other American sulfur company. It has developed three deposits, two in Texas and one in Louisiana, and has also produced other minerals.

In 1912 there was only one American sulfur producer, and well over half of

all domestic sulfuric acid was being made from foreign pyrites. The Freeport incorporators who set about to increase the domestic sulfur supply were Eric P. Swenson, a Texan, who became president; his father, S. M. Swenson, the first Swede to migrate to the state; three other Texans, William T. Andrews, Charles A. Jones, and Frank Hastings; and Sidell Tilghman of New Jersey. This group undertook to develop a salt dome type of sulfur deposit known as Bryanmound in Brazoria County southwest of Houston. The discovery of oil in 1901 at the fabulous Spindletop Dome had touched off a wild scramble for mineral rights at other Gulf Coast domes, and during the early years of the century Bryanmound was drilled a number of times for oil and then for sulfur. The Freeport group acquired the sulfur rights and set about to mine sulfur by the Frasch hot-water process. Nov. 12, 1912, the first ton of sulfur was produced. Meanwhile, a few miles east of the mine, the new town of Freeport was being built to provide homes for workers.

For the next few years, the Company encountered production difficulties and had to make various replacements and additions to the mining plant, which increased the annual rate of production from 10,000 tons in 1913 to about 260,000 in 1916. Changes were made, too, in the corporate structure. The Freeport Texas Co. was formed in 1913 as a holding company for the original sulfur-producing company and for five other working subsidiaries created to perform shipping and other related functions.

The war-induced expansion of domestic sulfur production and consumption—Bryanmounds's annual rate for 1917-18 was almost double that of 1916—established Gulf Coast sulfur as the major raw material for sulfuric acid in the United States. Moreover, the export market for Gulf Coast sulfur was stimulated by the formation in 1922 of the Sulphur Export Corp. (Sulexco), under the Webb-Pomerene Act, enabling American producers to collaborate in foreign selling. Freeport thenceforth conducted most of its export sales through Sulexco. In the face of other greatly expanding domestic sulfur production and the industrial slump, however, Bryanmound production was curtailed after the war. Its output increased once more during the latter 1920's, but never again reached the World War I peak. The deposit became depleted and the mine was shut down Oct. 1, 1935, after having yielded 5,001,068 tons during its 23 years.

Well before Bryanmound neared exhaustion, Freeport had begun developing Hoskins Mound, also in Brazoria County but on the opposite side of the town from Bryanmound and about 15 miles away. Like Bryanmound, Hoskins Mound had been prospected for oil as far back as 1902, but not for sulfur. Freeport acquired the sulfur rights in 1922 and on Mar. 31, 1923, the first sulfur was produced. Formation conditions, however, hampered satisfactory production. Underground channels were draining the hot water away from the well area and lowering the temperature there below that necessary to melt the sulfur. Wilson T. Lundy, then superintendent, and now vice-president, and his staff, after much experimenting succeeded in forcing mud into the formation. Through this unique method of controlling the escape of hot water, production in 1927 increased 70% and in 1928 rose above the war peak achieved by Bryanmound.

Other improvements were developed at Hoskins, where the sulfur was located at greater depths than other Gulf Coast mines and was overlain by harder formations. Unusually large drilling rigs with hydraulic rotary tables were introduced, a special type of core bit was devised, and special mobile equipment was designed. Other operating improvements included a process for reheating and re-using bleed water removed from the mine, a process for recovering heat from stack gases, methods and equipment for regulating the temperature of water pumped down

individual wells. Hoskins Mound production was curtailed during the early 1930's and then increased substantially. It was further increased during World War II for which the Army-Navy "E" was awarded four times. Since the end of the war, it has continued producing and, at the end of 1946, had a total record of 8,466,955 long tons of sulfur.

In 1930 Freeport stockholders voted in a new management headed by Langbourne M. Williams, Jr., a native of Richmond, Va., who subsequently became president. The Williams family, through the private banking of John L. Williams & Sons of Richmond, had been associated with Freeport since 1912. A program of exploration for new reserves and investigation of opportunities for expansion led to development of a new sulfur mine, Grande Ecaille, acquired Feb. 1932, to production of new mineral products, and to various changes in the corporate structure. The original sulfur-producing company and other working subsidiaries were dissolved, and the name of the holding company, Freeport Texas Co., was changed back in 1936 to Freeport Sulphur Co.

At Grande Ecaille Dome, located in Plaquemines Parish on the Mississippi Delta south of New Orleans, Freeport came up against problems unknown at Bryanmound and Hoskins: the surface above the dome was nine-tenths marshland and one-tenth shallow water. The instability of the terrain and the difficulty of transporting equipment and materials to the site magnified the usual construction difficulties. Every structure had to be built on mats of heavily reinforced concrete supported by piling. As a connecting link with the outside, a 10-mile canal was dredged from the mine site to the relatively firm west bank of the Mississippi River, where the town of Port Sulphur was built to provide homes for workers and their families. The first ton of Grande Ecaille sulfur was mined on Dec. 8, 1933.

As at Freeport's other mines, initial production signaled more troubles. Again underground formations diverted hot water and had to be overcome by mudding. A discoloration due to reactions between the molten sulfur and traces of crude oil took two years of research and study to remove through a new distillation process. With the solution of these problems, production increased substantially, doubling during World War II. Like Hoskins, Grand Ecaille won the Army-Navy "E" award four times. Postwar, Grande Ecaille production made a new record by operating at abnormal rates. To maintain this permanently, an expansion program to enlarge the production and shipping facilities was in progress at the end of 1946, at which time Grande Ecaille had produced a total of 6,439,135 long tons of sulfur.

The policy of actively seeking new opportunities to expand the scope of Freeport activities and broaden its base of earnings led to the production in the early 1930's of a second product, manganese. Freeport purchased the controlling interest in Cuban-American Manganese Corp., which in turn owned all the stock of Cuban Mining Co., owning or leasing deposits of low-grade manganese oxide ores in Oriente Province, Cuba. To utilize these ores for the manufacture of steel, a way had to be found to concentrate them to ferromanganese grade. Research previously sponsored by David M. Goodrich and F. S. Norcross, Jr., and subsequent Freeport research indicated flotation, a process not then adapted to manganese. Construction of a plant near Santiago was completed in 1932 and production began in June.

For several years the operation was beset by numerous technical difficulties, in addition to floods, earthquake, and hurricane. By extensive equipment changes and additions, the annual rate of production, originally averaging 50,000 tons of ore, was increased to over 100,000 tons in 1937, and by expanding the concentrating plant, to over 150,000 tons during the war. The Company also supplied substantial amounts of other ores through a local ore-buying program to encourage small

Cuban operators. During 1946 the ore deposits became depleted and the concentrating plant was shut down in December, after a total production of 1,443,962 tons. The purchased-ore program increased this total to 1,567,662 tons. As the Cuban-American Manganese Corp. had fulfilled its purpose, it was dissolved and its assets distributed.

Another result of Freeport expansion policy was the production of nickel. In 1940 the Company acquired an interest in extensive deposits of low-grade nickeliferous iron ores blanketing the hills of northeastern Cuba and undertook research to develop a recovery process. The U. S. Government became interested in this effort to open a new nickel source, and shortly after Pearl Harbor the Reconstruction Finance Corp. entered into contracts with a new Freeport subsidiary, Nicaro Nickel Co., for the development of these ores. Freeport owned the common stock of Nicaro and the Government, the preferred.

Starting from scratch during a period of the worst wartime material and transportation bottlenecks, Nicaro began constructing a large mining and metallurgical plant. There was no time to test the research results on any sort of commercial scale. A transition had to be made from small pilot plant to large commercial operation. Construction was carried on simultaneously with design of the plant which began operations in Oct. 1943. The nickel was recovered as nickel oxide by an ammonia leaching process developed by Freeport engineers. In 1944, on a partial production basis, about 10,000,000 lb. of contained nickel had been produced, and subsequently about 25,000,000 lb. per year. The oxide gained widespread acceptance for use in stainless and other high-alloy steels and after the first year, the production cost per pound was less than the price obtained by the Government for the product, there being no charge for depletion.

Freeport today is greatly different from the infant company that began operations at Bryanmound in 1912. The combined sulfur production for Grande Ecaille and Hoskins is now well over 1,000,000 tons a year. In addition, Freeport has expanded its activities and acquired new interests. At the start of 1947 total assets amounted to approximately $34,000,000, of which about $20,000,000 was cash and government bonds. Its 800,000 shares of common stock were owned by approximately 11,000 shareholders from every state.

Much of this progress has been made since 1930 under the management of president Williams and his associates. John H. Whitney served as chairman of the board from 1934 until 1942, when he resigned to enter military service. Principal officers, all but one with Freeport since 1930, include R. K. Shirley, vice-president and treasurer; Peason E. Neaman, vice-president and secretary; and four vice-presidents, M. B. Gentry, Wilson T. Lundy, Lewis Mims, and Fred S. Norcross, Jr. Present directors, nearly all of whom have served since 1930, are George G. Battle, Elmer G. Diefenbach, David M. Goodrich, Wilson T. Lundy, Lindley C. Morton, Godfrey S. Rockefeller, W. S. S. Rodgers, Chauncey Stillman, Edward H. Thaete, Alan Valentine, Edwin S. Webster, Jr., John H. Whitney, and Langbourne M. Williams, Jr. Under their leadership Freeport is continuing its exploration for new deposits of sulfur and other valuable minerals, and its investigation of new opportunities for expansion.

FRIES BROS. INC., was organized about the turn of the century by Dr. Harold H. Fries for the purpose of manufacturing, importing, and distributing fine organic chemicals. A connection with Société Chimique des Usines du Rhône, which lasted for a number of years, led to the early manufacture of vanillin, saccharin, resorcinol, and ethyl chloride, which latter was sold for anesthetic purposes in autospray glass tubes under the trade name Kelene. The Trillat

method of disinfection using dry formaldehyde gas was brought over here from France and installed by a number of city Boards of Health.

In 1916 reconstruction of the Bloomfield, N. J., plant was begun and completed in 1918, with new equipment for the manufacture of aromatic chemicals. Since then production has been greatly expanded to include organic medicinal, industrial, and insecticidal chemicals, the number now totaling well over 100. The Company was the first American manufacturer of ethyl vanillin, synthetic menthol, esters of *p*-hydroxybenzoic acids (preservatives), homomenthol (cyclonol), homomenthyl salicylate (ultraviolet filter), cresophan (a specific against athlete's foot), glycosine (dulcin-synthetic sweetner), and several antioxidants for stabilizing food, drugs, and oils.

The Company was incorporated in 1941 under the management of president Harold H. Fries, vice-president F. E. Stockelbach, secretary K. V. Stockelbach, and treasurer G. V. Cooke.

FRITZSCHE BROTHERS, INC. (originally known as Fritzsche, Schimmel & Co.) was founded on Aug. 28, 1871, in N. Y. City, by Paul Traugott Fritzsche, a brother and copartner of Herman T. and Ernest T. Fritzsche of Schimmel & Co., Leipzig, Germany, established in 1829.

In the middle of the 19th century the American essential oil industry was of minor importance. Production was haphazard and crude methods inhibited supply and quality. Little was known about the chemistry of essential oils, in which Fritzsche Bros. was destined to play an important role, and less about their cultivation and production in remote parts of the world. The importance of synthetics was as yet unrecognized.

Though at first engaged chiefly in the importation of essential oils and flavorings, Fritzsche Bros. was not long in developing its own resources. Within a few years a factory was opened in Hoboken, N. J., where fruit esters were manufactured and croton oil was pressed. This factory was transferred in 1892 to Garfield, N. J., its directors being in turn Dr. Frederick B. Power and Dr. Clemens Kleber—both well known for their contributions to the chemistry of essential oils. This plant was sold in 1900, but a few years later Dr. Kleber organized his own manufacturing plant in Clifton, N. J., where he produced exclusively for Fritzsche. Upon his death in 1937, this factory was purchased by the Company, enlarged, and modernized.

The First World War, which severed relations with foreign sources, played havoc with the quality of oils available in the market, and emphasized problems of supply. An immediate remedy was called for, an intensive investigation of production methods and sources of supply, as well as careful laboratory anaylsis. In 1925 Fritzsche Bros. began such an investigation, a study of world sources, which continues today. Between 1925-45 Dr. Ernest S. Guenther, chief chemist, visited every important essential-oil producing center in the world. His field studies resulted in a massive collection of data and a unique picture of conditions prevailing in the trade. Painstaking studies were made of methods of cultivation, harvesting, and distillation of hundreds of essential oils.

Up to this time much confusion had existed regarding many oil standards. Dr. Guenther's work made it possible for Fritzsche Bros. to examine and analyze authentic samples which had been carefully supervised in every phase of production, and to establish standards of quality where none had previously existed. Thus Fritzsche Bros. has contributed not only new products—oils, synthetics, aromatic chemicals—which have come out of its laboratories, but emphasis upon essential oil chemistry and as a concomitant, elevation of standards.

Steady expansion of the Company's business has necessitated the establishment

of branches and stock depots throughout the United States, as well as in Canada and Mexico. At the present time the Company maintains branches in Atlanta, Philadelphia, Cincinnati, Cleveland, Dallas, Detroit, and San Francisco; branch offices and stocks in Boston, Chicago, Los Angeles, St. Louis, Toronto (Fritzsche Bros. of Canada, Ltd.), and Mexico City (Productos Fritzsche Bros. S.A.); factories in Clifton, N. J., Carroll County, Md., Seillans (Var), France.

In its 76 years, Fritzsche has had only four heads. The founder, Paul T. Fritzsche, died in 1886, and was succeeded by Carl Brucker. Upon Brucker's death in 1913, Frederick E. Watermeyer succeeded him. The firm became fully independent of its Leipzig connections in 1919 when it incorporated with Watermeyer as president. Under his guidance the Company began a policy of expansion and intensive scientific research which was continued and expanded by his successor, Frederick H. Leonhardt, who was elected president following Watermeyer's death in 1934.

In addition to president Leonhardt, the Company officers are: John H. Montgomery, 1st vice-president and treasurer; Hans P. Wesemann, 2d vice-president and secretary; Dr. Ernest S. Guenther, 3d vice-president and chief chemist; Joseph A. Huisking, 4th vice-president; Fred H. Leonhardt, Jr., 5th vice-president; Dr. Darrell Althausen, manager, Clifton plant; John R. Cassullo, assistant treasurer; Daniel A. Neary, assistant secretary; and Gustave A. Wohlfort, comptroller. Leonhardt, Montgomery, Wesemann, Huisking, Guenther, Fred H. Leonhardt, Jr., and B. F. Zimmer, Jr., comprise the board of directors.

To encourage theoretical studies in the field, Fritzsche has at various times established fellowships and grants in several colleges and universities. The first of these was at the University of Wisconsin in 1917, and continues in effect. A series was maintained at Columbia University from 1925-29. Since 1940 a fellowship has been supported at Michigan State College. In addition, numerous outright grants have been made to further important work by individuals and institutions.

In accord with this tradition of interest in research, Fritzsche celebrated its 75th anniversary in 1946 by the establishment of an annual award, to be known as "The Fritzsche Award." This will be presented annually for outstanding achievement in the field of essential oils and related chemicals. It will consist of a gold medal and a substantial cash award and will be administered by the American Chemical Society.

GANE AND INGRAM, INC., was organized in 1926 by Eustace H. Gane and Peter T. Ingram as sales agents for chemicals and medicinal products and eventually manufacturers of synthetic medicinal chemicals, in increasing demand since the end of World War I.

Late in 1928 they organized a subsidiary, Ganes' Chemical Works, Inc., to manufacture barbiturates and ephedrine in a plant at Carlstadt, N. J., managed by Dr. J. G. Schudel. Before long the plant was producing phenobarbital, barbital, and a number of alkaloids. With the increased shipments of ma huang from China, production of ephedrine grew until over 1,000,000 lb. of the herb had to be imported yearly to satisfy the growing business. When it became established that the active principle in Prontosil is sulfanilamide, the Company was one of the first to enter into large-scale manufacture of sulfanilamide, and later on became a pioneer in the manufacture of nicotinic acid and nicotinamide.

In 1934 A. Maschmeijer, Jr., Inc., was formed for the manufacture of synthetic menthol and a plant was built at Newark, N. J. The Company's success with this compound permitted it to enter into the manufacture of many other aromatic

chemicals as by-products and as new chemicals. Unfortunately Gane died before the Newark plant was completed and its expansion was left to his associates. Among its outstanding items are synthetic musks—musk xylol, musk ketone, musk ambrette—benzyl products, and a number of intermediates important in the manufacture of sulfa drugs, penicillin, etc.

During World War II, the Company supplied various government departments with medicinal chemicals and intermediates, benzyl benzoate, and synthetic epinephrine. When the shortage of caffeine precluded any further manufacture of theophylline, the Carlstadt plant developed a synthetic process for theophylline which is now being manufactured in sufficient quantities to take care of the country's demands and has helped also to take care of the growing demand for aminophyllin. The shortage of natural adrenalin prompted the Company to develop its production of synthetic epinephrine, now produced in sufficient quantities to take care of domestic demand and export. In bile salts the Newark plant has developed a process for cholic, dehydrocholic, and desoxycholic acids for which the demand has greatly increased.

In 1934 Peter T. Ingram succeeded Gane as president of all three companies. On the death of Charles C. Karr, secretary of the original corporation, B. F. Knopp became secretary of both the parent and associate companies.

GENERAL ANILINE & FILM CORPORATION is a merger of the American I.G. Chemical Corp., incorporated in Delaware in 1929, with the General Aniline Works, Inc., Agfa-Ansco Corp., and Ozalid Corp., which three companies became operating divisions. The change of name from American I. G. Chemical Corp. to General Aniline & Film Corp. was made in 1939. General Aniline manufactures dyestuffs, intermediates, textile auxiliaries, and such specialties as carbonyl iron powder, surface-active agents, including detergents, and emulsifiers through its General Aniline Works Division; cameras, film, and photographic accessories through its Ansco Division; and dry development whiteprint machines and sensitized materials through its Ozalid Division. A fourth division, Antara Products, is a sales organization which handles surface-active agents and other miscellaneous chemical products. Dyestuffs and textile auxiliaries are sold through General Dyestuff Corp., its sole selling agent for these products.

General Aniline Works originated as the Albany Aniline & Chemical Co., founded by Arthur Bott in 1868, marking the beginning of the coal-tar dyestuff industry in the United States. The first plant was in a residential section whose dwellers strongly opposed the company's activities, particularly when the making of magenta left a reddish tinge over the neighborhood. This agitation forced removal to Broadway near the Hudson River in Albany, in 1870.

Bott had been in the colored paper and cardboard business before he went into coal-tar dyes as the result of having met A. W. Hofmann—father of the "Hofmann reaction"—in Germany in the 1860's. His venture was not a complete success and after three or four years he returned to his old business. His colleagues carried on and in the early 1870's, through the help of Carl Rumpf, New York representative of Farbenfabriken F. Bayer & Co. and others in the plant, Herman Preiss, a foreman from Bayer, was sent over to take charge of production. He made magenta successfully for a number of years. About 1880 Rumpf returned to Germany, Bayer & Co. having disposed of the stock it had acquired; the mortgage on the plant was foreclosed; a creditors' committee took over the management; and finally in 1900 the plant was closed.

In the meantime the Hudson River Aniline & Color Works had started to make dyestuffs in Rensselaer. It had been organized in 1882 by Herman Preiss and

William Lesser, a chemist formerly with the Albany Co., and financed by Louis Waldman, an Albany department store owner. Soon after, the Bayer Co., through E. Sehlbach, its American representative, put about $10,000 into the company which was successful from the start and made soluble blues, alkali blues, Bismarck browns, and fuchsin crystals. Production in 1903 was about 300,000 lb. with 100,000 lb. of soluble blues the largest single product.

However, disagreements arose, mainly because Bayer & Co. had limited production to items for the leather trade—no textile dyes were being made at Rensselaer—and so in 1898 Waldman organized the American Color & Chemical Co. and acquired land opposite Rensselaer where a plant was built. Dr. Von Salis came over from Manchester, England, to manage the plant and a year later, A. W. Dawes, a young Manchester associate of Von Salis, joined him. Under Von Salis and Dawes, textile dyes and a few intermediates were made. The business prospered, but not for long. Lack of sales organization, a destructive fire, other dye plants in America, and a price war all led to a drop in business. In 1903 the plant was liquidated and Von Salis and Dawes went to work for Hudson River Aniline across the river.

In 1905 the Rensselaer plant started to make pharmaceuticals and new buildings were erected to accommodate the new field, as well as for increased production of dyes. In 1910 the company name was changed to Farbenfabriken of Elberfeld Co. and this was changed in 1913 to the Bayer Co.

When World War I broke out, there were seven dyestuff plants in the United States, employing 528 people, and manufacturing about 6,000,000 lb. a year valued at about $2,500,000. The Rensselaer plant was third, with 17% of the business. With the dye shortage, and high prices, the dye plants all embarked on expansion programs and at Rensselaer three buildings were erected in 1915, when production of nitro and amino derivatives of benzene was started. The Azo Department was set up in 1916.

In 1917 the Alien Property Custodian seized the Bayer Co. and sold it at public auction to Sterling Products which was interested only in pharmaceuticals, particularly aspirin, and so it resold the dyestuff-producing section to Grasselli Chemical Co. Grasselli started in the dye business just in time to feel the depression of 1921 and it had opened negotiations with the old owners, so that in 1924 Bayer and Grasselli came to an agreement that resulted in the Grasselli Dyestuff Corp. Buildings were renewed, worn-out equipment replaced, and a program adopted to strengthen the whole company. In 1925 the manufacture of H acid, gamma acid, and other intermediates was started in the Grasselli, N. J., plant (then, as now, operated in conjunction with the Rensselaer plant), and from that time production was on a firmer basis. The Rensselaer plant was the first to make solid diazo salts in the United States, in 1927, when the range of naphthol AS colors was increased. Later came the nitrosamines and rapid fast colors, triphenylmethanes, azines, acridines, euchrysines, and phosphines.

The Grasselli, N. J., plant was started in 1915. Caesar A. Grasselli believed it would be a mistake to make dyes and heavy chemicals on the same lot, and so the dyestuff plant was built across the tracks of the Jersey Central R.R. from the heavy chemicals plant which had been in existence some years. Adolf Wock, a chemist, is supposed to have given the Grassellis the idea of entering the dyestuff field. The first dyes made at Grasselli were of the sulfur type, principally sulfur blacks. In 1918 the line was enlarged to include alizarin colors, which with sulfur colors and a few intermediates made up production until 1924, when Bayer re-entered the picture. Grasselli Dyestuff Corp. continued to operate the two plants under that name until 1928, when I.G. Farben assumed complete control and

changed the name to General Aniline Works, Inc. Following this, the Vat Color Department was set up.

During World War II about 50% of the Government's requirements for vat colors was supplied by General Aniline, which is the largest manufacturer of these dyes in the United States. At the present time (1948) these plants employ nearly 4,000 and produce about 75,000,000 lb. dyes and intermediates annually. The dye list has grown to a nearly full range of vats, azos, triphenylmethanes, alizarins, algosols, heliogens, naphthols, rapidogens, cellitons and cellitazols, lake colors, azosols, nigrosines, and sudans. In addition, these plants manufacture detergents, surface-active agents, and emulsifiers for the textile, industrial, and household trade, as well as mothproofing and waterproofing compounds, mildew preventives, etc.

Ansco Division of General Aniline was founded in 1842 by Edward Anthony, Columbia University graduate who had taken lessons in daguerrotype from Samuel F. B. Morse, a disciple of Daguerre. Anthony was so apt a pupil that in 1841 his photographs of the Canadian highlands along the American boundary were used by the Government to establish boundary claims. Anthony's first shop was opened at 309 Broadway in N. Y. City, where he was joined in 1852 by his brother Henry. The shop became headquarters for devotees of photography and the Anthony brothers became manufacturers as well as dealers of photographic equipment. Their experiments resulted in many contributions to the art. Henry Anthony is credited with being the first man to take an instantaneous photograph, father of the modern snapshot.

In 1902 the Scovill Manufacturing Co. of Waterbury, Conn., which began making daguerrotype plates in 1842, joined with Anthony & Co. to form the Anthony & Scovill Co. Meanwhile three great developments had advanced the art: the wet-collodion process, the gelatin dry plate, and the flexible film, invented in 1887 by Rev. Hannibal Goodwin of Newark, N. J.

The Anthony-Scovill merger took place four years after Edward Anthony's death and was directed by his son, Richard, who decided to move manufacturing to Binghamton, N. Y. In 1928 the Ansco Co., as the firm was later called, became Agfa-Ansco Corp. when it was merged with the American interests of Agfa Film. This merger made possible distinguished contributions to photography: infra-red film; Supreme and Ultra-speed Pan, and the amazing Super Pan Press film, placed on the market in 1937, which had an emulsion speed three to four times greater than any previously available. Ansco color film was released in 1943, then only to the Armed Forces. It is the first subtractive-type color film for making full-color transparencies in ordinary roll-film cameras and can be processed by the user. Facilities for the manufacture of color products as well as black and white are being expanded at Ansco, which plans to enter the motion picture film market to an increasing extent. Ansco is the second largest manufacturer of photographic materials in the United States, employing about 4,000 at Binghamton and sales and distribution points in the principal cities.

Ozalid Division of General Aniline is the principal manufacturer in the United States of dry development whiteprint machines and sensitized materials. The Ozalid process, based on the light sensitivity of diazo compounds, was discovered during World War I by a Franciscan monk named Kogel, who was a professor at the Karlsruhe Technical Institute. Kalle & Co. of I.G. Farben, became interested in the diazo-sensitized paper that yielded a positive image upon exposure to an alkaline vapor, as a successor to blueprinting. It commenced the manufacture of machines and paper in the early twenties and in 1925 entered into an agreement with Eugene Dietzgen Co., the engineering and drafting-room supply house, under

which Dietzgen introduced Ozalid to the American market, importing machines and sensitized paper from abroad. Under Dietzgen, Ozalid sales reached about $250,000. In 1933, due to the depression and other factors, the Ozalid Corp. was formed to take over the sales. This was soon found to be uneconomical and a license agreement was reached with Kalle, whereby Ozalid manufacture was started in Long Island City. The first machine was made in Mar. 1935 and at a cost of $85, compared with the imported machine, seven times as heavy, costing about $500. In 1938 manufacturing operations moved to Johnson City, N. Y., and since then Ozalid has opened paper-sensitizing plants in Detroit, and Oakland, Calif., and its sales have increased 1500%.

What has been called "the German influence" (meaning the I.G. Farben phase) in General Aniline & Film Corp. as now constituted, had its beginning in the deal between Grasselli and Bayer in 1924 and came to an end early in 1941.

The U. S. Government's interest in the Corporation became active June 18, 1941, six months before Pearl Harbor, when General Aniline had to do business under a license as a "generally licensed national." Upon our entry into the war, the foreign interest, amounting to nearly 98% of the stock outstanding, was seized by the Foreign Funds Control Unit of the Treasury Department which installed four American businessmen of distinguished reputation and ability with directions to Americanize the Company and conduct its business for the fullest contribution to the war effort: Robert E. McConnell, a retired mining engineer and banker, became president. George Moffett, chairman, Corn Products Refining Co.; Robert E. Wilson, chairman, Standard Oil of Indiana; and A. E. Marshall, president, Rumford Chemical Works, became vice-presidents. They remained in office, Mar. 1942-July 1943, when George W. Burpee, a well-known consulting engineer of Coverdale & Colpitts was named president and the four men originally installed withdrew. Under McConnell and Burpee the broad objectives laid down by the Government were accomplished. The Company's war record was impressive and included an Army-Navy "E" award for each of its manufacturing plants.

A major achievement of the American management was the creation in 1943 of a research organization, previously unprovided for because of the availability of I.G. Farben's research. At present, the laboratory at Easton, Pa., has a total personnel of nearly 400. When General Aniline was vested by the U. S. Government, it was the assignee of thousands of I.G. patents which have provided its research and development staff with a vast amount of scientific knowledge. Early in 1948 the Company announced the availability of these patents for licensing on reasonable terms. Its most interesting postwar operations are concerned with research and development in the field of high-pressure acetylene.

In Aug. 1947 Jack Frye, former president of Trans World Airlines, succeeded George W. Burpee as president and chairman of the board. During 1948 the Company's sales and profits have reached all-time high figures.

GENERAL CERAMICS AND STEATITE CORPORATION is one of many interesting examples of the Americanization and expansion of a transplanted European industry. The manufacture of chemical stoneware such as condensing coils, plug cocks, tanks, and other equipment, was initiated by the famous British potters, Wedgwood and Doulton, early in the 19th century to meet the demand of the British chemical industry, then the world's largest producer of heavy chemicals.

In 1836 Ernst March established a pottery in Charlottenburg, Germany, and his son Paul who, while studying in England realized the value of ceramic equipment to the chemical industry, took up the manufacture of chemical stoneware. From

this modest beginning, largely by consolidation with other European chemical stoneware plants, was evolved the Deutsche Ton-und Steinzeugwerke of Charlottenburg. This achievement was the work of the late Dr. Nicolaus B. Jungeblut, an American citizen of Dutch antecedents, who was for many years the dominating figure in this field.

In 1906 exports of chemical stoneware equipment by the Deutsche Ton-und Steinzeugwerke to North America clearly indicated the need for an American plant and the Didier-March Co. was organized to manufacture chemical stoneware under supervision of Deutsche Ton-und Steinzeugwerke and refractories under Stettiner Chamottefabrik. The following year plants were built at Keasbey near Perth Amboy, N. J., by Frederick J. Mayer, formerly of Bartlett-Hayward Co., Baltimore, and a corps of highly skilled craftsmen was sent from abroad. Two Englishmen, Percy C. Kingsbury and Frederick A. Whitaker, then employed by the German company, were also sent over, Kingsbury becoming chief engineer and Whitaker superintendent of the stoneware plant, from which he retired in 1945. To them belongs the credit for the chemical applications of ceramicware and progressive improvement in ceramic bodies and manufacturing techniques, making possible equipment of larger capacities, closer tolerances, and resistance to great chemical, mechanical, and thermal abuse.

The chemicalware branch of the new enterprise was successful but the refractories branch burnt down and was ultimately sold to the Carborundum Co. The German-American Stoneware Works, with Jungeblut as president, was organized to handle the stoneware business exclusively. It shortly purchased the Phoenix Ceramics Works at Metuchen, N. J., manufacturers of sanitary porcelain. This Plant #2 made special chemicalware by the casting method, particularly whiteware and porous diaphragms, which was transferred to the main plant following the sale of the sanitaryware plant in 1945 to the Richmond Radiator Co.

In 1913 Plant #3 was erected at Keasbey for the manufacture of gas-mantle rings and other accessories for gas lighting and heating to which were later added small refractory shapes. Here was also made tower packing, particularly Raschig rings, at first by an exclusive and later by a nonexclusive license to the Raschig patent. A natural development was the production of electrical porcelain, including insulators, heater plates, and spark plugs.

During World War I the Company faced a sudden skyrocketing demand for chemicalware and a cutting off of raw materials, 80% of which came from Germany, and technical information from the parent plant. Acceptable raw materials from domestic sources were found. The name of the corporation was changed to General Ceramics Co. and the foreign holdings sold by the Alien Property Custodian to an American syndicate, but with no change in technical personnel.

In 1919 a small chemical stoneware plant in Brooklyn, the Chas. Graham Chemical Pottery Works, went out of business and general manager Robert S. Beecher with several expert potters joined General Ceramics. Beecher later went to Chicago where he represented the Company for many years until his retirement in 1942. Plant #4 built at Keasbey in 1920 manufactured fused-silica chemical equipment which was excellent, but local conditions made the enterprise unprofitable and it was abandoned two years later.

At plant #3 at Keasbey, steatite was found to be superior to porcelain for many electrical purposes, and at the beginning of World War II this plant was one of the largest producers of steatite insulators in the United States. In recognition of this, the Company name was changed to General Ceramics & Steatite Corp. in 1944. The Company maintains selling agents in the Buffalo-Niagara Falls area, Chicago, and on the Pacific Coast, covers other domestic markets, and has represen-

tatives in Canada, Mexico, South America, and important chemical manufacturing areas throughout the world.

Two laboratories are operated for control and research. Contributions are made from time to time to the research equipment of the Ceramic School of Rutgers University in order to make it available to the ceramic industry throughout New Jersey. Research work is now in progress on producing high-fired porcelain chemical equipment of dimensions heretofore considered impracticable, this work being a continuation of that undertaken in connection with the atomic bomb project. New equipment now regularly produced includes white, iron-free stoneware of zero porosity for pharmaceutical purposes and various bodies of increased conductivity, tensile strength, or density, low thermal expansion, and varied porosity.

GENERAL CHEMICAL COMPANY has its roots deep in the latter part of the 19th century, a period of rapid national development in which the heavy chemical industry participated. Heavy chemical plants were then small, and service to the customer was not of a high order with respect to quality, strength, and sometimes dependability. For the most part processes were the old ones developed in Europe years before, which had undergone little or no improvement in this country. Believing that to pool their resources would provide greater financial strength and enable them to effect economies in operation, while at the same time permitting broader research and better service to their customers, Nichols Chemical Co. and 11 others in the heavy chemical field consolidated in 1899 to form General Chemical Co. The 11 included Nichols Chemical Co., Martin Kalbfleisch Co., Chappel Chemical Co., Jas. Irwin & Co., National Chemical Co., Dundee Chemical Co., Fairfield Chemical Co., Passaic Chemical Co., Lodi Chemical Co., Jas. L. Morgan & Co., Moro Phillips & Co., and Highlands Chemical Co.

The plants of the component companies were located near the industrial centers of Philadelphia, New York, Pittsburgh, Buffalo, Cleveland, Chicago, St. Louis, and in eastern Canada. The products offered numbered 33, with sulfuric acid by far the most important. Other principal chemicals included muriatic, nitric, acetic, and hydrofluoric acids, sulfate of alumina and related alums, and sulfate of soda (crude salt cake and refined Glauber's salt). All of these involved the use of sulfuric acid as a raw material.

During the last quarter of the 19th century, advancement demanded a stronger, purer commercial sulfuric acid than the 60° Bé "chamber acid" then being produced in Europe and America by the old lead chamber process. At the time of the consolidation in 1899, all of General's production of sulfuric acid was made by the chamber process, some of which was further concentrated to 66° Bé. Concentration was expensive and oleum could not be produced at all by this means.

For many years chemists in Europe had been seeking some method, carried out in the absence of water, that would produce strong acid (even oleum) directly. In 1901 its successful accomplishment was announced in Germany. The new "contact" process would yield acid of a high degree of purity in any strength desired by industry. The young General Chemical Co. appreciated the great economic possibilities of this process and undertook to develop it. Three years later it had brought this research to a full-scale plant operation. Subsequently it also acquired United States rights under the German process.

General Chemical's early interest in hydrofluoric acid was evidenced by construction of two new plants. These were of a new type, continuous in operation, which had been developed by Company research. During this period the old laborious hand-operated furnace for the manufacture of muriatic acid was replaced by

larger, mechanically operated furnaces. Nitric acid, now generally prepared from ammonia, was then made from nitrate of soda imported from Chile..

In its early days General Chemical built a plant to produce phosphoric acid from sulfuric acid and phosphate rock, the acid going to make phosphate of soda by a process with many new features developed by the Research Department. It has always figured prominently as a manufacturer of aluminum sulfate, a large consumer of sulfuric acid, and made much progress in developing suitable methods of utilizing various raw materials which offered economic advantages. The Company gradually became an important producer of sodium salts: crude salt cake; Glauber's salt; mono-, di-, and trisodium phosphate; tetrasodium pyrophosphate; sodium hyposulfite; sodium sulfide; sodium silicate; bisulfite of soda; and sodium fluoride.

A few years after its formation, General Chemical acquired Baker & Adamson Co. at Easton, Pa., which had built up an extensive business in C.P. chemicals used by college and industrial laboratories. Accustomed to dealing in hundreds and thousands of tons, the Company now had to adjust its thinking to small quantities at relatively high costs and prices.

Early in the century, entomologists had shown that much could be done to improve crop quality and production by the use of insecticides. General Chemical, wishing to participate in this new chemical market, entered the field in 1909, producing its first insecticides in the plant of a subsidiary, the Thomsen Chemical Co. of Baltimore, and later marketing them under its own name. Several new insecticides were developed and others improved during this period, the more important being lead arsenate, paste and powder, calcium arsenate, zinc arsenite, and lime-sulfur solution. Fungicides included "atomic" sulfur and Bordeaux mixture.

The Company's growing need for raw materials led it into several mining operations. Following its development of a process for burning pyrrhotite ore for the manufacture of sulfuric acid, General Chemical in 1904 organized Pulaski Mining Co. (absorbed in 1913) to take over a deposit of the ore at Galax, Va. Pyrites was also mined at Sulphide, Ont., and three years later, the Pulaski Foundry & Machine Co. was acquired. Since then, this facility has manufactured much special equipment used in General Chemical's plants.

Although the United States did not actually enter World War I until 1917, long before that time it was supplying very large quantities of materials to the Allied armies. The great increase in production of manufactured goods and particularly explosives set up a new demand for sulfuric and nitric acids in quantities which the industry was totally unable to supply.

Sulfuric acid was indeed the key chemical of the war period. To make available strong sulfuric acid required for explosives, General's contact plants everywhere were driven at maximum capacity. A few years before, sulfur produced by the Frasch process, came into the market from Louisiana. More acid could be produced from brimstone than was possible with sulfide ores. To stimulate production, this raw material was used to supplement ore and some units were converted entirely to brimstone. Large quantities of 60° chamber acid were available in the Middle West as a by-product from the zinc smelters. General had previously demonstrated commercially that such acid could be fortified with SO_3 (made in the contact process) to high-strength acid without the aid of concentrations plants. Large quantities of this 60° chamber acid were thus used to swell the production of strong acid. Nothwithstanding all these efforts, the capacity of the 44 contact units at 10 plants operated by the Company in 1914 was far short, and an expansion program was carried on until the end of the war. At the time of the Armistice in 1918, it had 62 units in operation in the United States, and Nichols Chemical Co., Ltd.,

a Canadian subsidiary of General, had six in Canada. Oleum, a relatively new industrial chemical since it could not be made by the chamber process, was essential for the manufacture of TNT. For some years General had made oleum in small quantities and now expanded this production rapidly to meet the military demand. It took only a small part in the great nitric acid expansion, as it was concentrating its efforts on sulfuric acid.

For many years research workers had sought to fix the nitrogen of the air in some usable form such as nitric acid or ammonia. The German chemical industry finally succeeded in thus producing ammonia and used this process during World War I. General Chemical, seeking new ways to expand its activities, had instituted research on the same subject in 1911 and in 1916 this project culminated in the development of an ammonia process different from any known up to that time. The Company made preparations to build a small commerical plant in 1917. The process was offered to the War Department and a large plant was partially completed when the war ended. This process was later carried into commercial operation by another subsidiary of Allied Chemical & Dye Corp.

Seeking an entry into the coal-tar and dye industry, General, in conjunction with Barrett Co. and Semet-Solvay, in 1910 organized Benzol Products Co. to manufacture aniline oil and salts. Thus when the war broke out, Benzol Products was ready to serve and it erected a new plant at Marcus Hook, Pa. In addition, General had independently undertaken at the Easton, Pa., plant the manufacture of hydroquinone and several other organic chemicals. The Easton plant was expanded during the war to make certain imported products shut off from Germany. In later years, the newly formed National Aniline & Chemical Co. took over this branch of General's business, together with Benzol Products and other organizations.

Even through business depression and perhaps in part because of it, the Company's research and development program was continued and a number of important advances in the art of acid making took place. Some of these were: a simplified process whereby cooling and purification of burner gases is made unnecessary when brimstone is used; substitution of vanadium catalyst for the expensive platinum catalyst; a commercial method for production of 40% oleum (20% oleum had been the standard); flash roasting of ores where available; improvements in engineering for more economical production of sulfuric acid. The Company built a plant at Buffalo to produce nitric acid by the new process employing ammonia and made oxalic acid by a novel process it developed.

A new aluminum sulfate plant was built to utilize clay from Company-owned deposits. This process had been the subject of much previous research. An interesting development was the manufacture of liquid alum in small plants built near consuming centers. A noteworthy expansion of sodium phosphate took place to meet the growing demand, also of sodium hyposulfite or "hypo" needed in the motion picture industry. Sodium metasilicate was produced for use as a heavy duty cleaner.

In World War I, the bulk of the acid used for explosives was 66° Bé and 98%. Relatively small amounts of 20% oleum were employed. The spent acid was concentrated and substantially all of it was re-used in explosives. Large quantities went to make nitric acid from nitrate of soda. In World War II, 66°, 98%, or even 20% oleum were not considered strong enough for TNT, and 40% oleum was necessary. 40% oleum cannot be made by concentration alone. The bulk of it must result from fresh contact process acid. Furthemore, none of the recovered acid was needed for nitric acid since this was produced by oxidation of ammonia instead of from nitrate of soda and sulfuric acid. It was foreseen that without adequate means

for utilizing the recovered acid in explosives operations, methods must be developed for its use by industry. As recovered from the nitrating operation it could not be satisfactorily used in this way. If dumped it would have polluted streams and new sulfuric acid producing capacity would have been needed to make up the loss.

An industry committee was appointed by the Government to study and recommend procedures. General took a leading part in this work and made notable contributions to the solution of the problems presented, including production of 40% oleum, purification of the recovered acid, and demonstration of the suitability of the purified acid for various industrial uses and partial employment in explosives plants. These developments reduced substantially the new acid capacity the Government was required to install. The Army Ordnance plants were able to avoid a very difficult waste-disposal problem and to purchase their acid requirements at a substantial reduction in cost.

In many ways General Chemical's part in World War II was a repetition of its role in World War I. Once again it was to make every ton of acid possible. The first move was to provide oleum facilities and these were added to existing acid plants as needed to meet explosives plant schedules. Every device was used to secure maximum output—concentration, fortification, brimstone where it would help, even shipment of 60° instead of 66° acid to customers in certain cases. The greatly increased quantities of aviation gasoline needed required more strong sulfuric acid (99%) as a catalyst. General Chemical built acid plants at three locations to meet this demand, including facilities to decompose the resulting impure spent acid. It constructed a large sulfuric acid plant at Front Royal, Va., for the rayon makers, and even in the last year of the war built four more units in existing plants in various critical areas. These units were of a more simplified type developed through Company research.

In one area, Meadville, Pa., (Keystone Ordnance Works) markets did not exist for economic disposal of all recovered sulfuric acid. General was prepared to offer a proven process whereby the recovered acid was broken down to sulfur dioxide, oxygen, and water. The water was condensed and the remaining SO_2 was purified and converted to 40% oleum. A large government-owned plant was built at Meadville by General Chemical Meadville Corp. (a subsidiary of General Chemical Co.) which started operation early in Oct. 1943 and fully met its projections.

General converted seven of its existing plants to manufacture of 40% oleum and designed, built, and operated 11 new contact plants. In addition, it carried on its normal business of supplying acid to American industry during the war.

Of the other acids made by General, hydrofluoric expanded most during the war period, due to demand for a new form, 100% anhydrous, as a catalyst for manufacture of aviation gasoline. This chemical was in heavy demand and was made by several other companies. General built four plants, each somewhat different, to take care of the situation. The manufacture of anhydrous hydrofluoric acid is now a well-established and economical operation.

In addition, General undertook a new activity: the manufacture of military explosives. Through a subsidiary, General Chemical Defense Corp., it operated for the Government the TNT plant at Point Pleasant, W. Va., which was a 12-line facility spread over 8,200 acres. The plant consumed 1,440 tons of oleum per 24-hour day and produced approximately half that quantity of TNT at full capacity. General Chemical sent several hundred highly trained employees, much needed in its own operations, to the Ordnance Works whose high place in the safety records was twice recognized by citations by the Department of Labor and its production by three Army-Navy "E" awards.

Over the years General Chemical had also continued its specialization in the

manufacture of agricultural insecticides and fungicides, developing a number of important inorganic and organic spray materials. In Feb. 1944, the War Production Board asked General Chemical to deliver 25,000 lb. of DDT by late summer. The first 5,000 lb. was furnished by June. The process was continuously improved until by Nov. 1945 output reached tonnage proportions. When DDT was no longer needed for military use, the Company manufactured DDT insecticides for agricultural and domestic use, which it placed on the market under its long-established Orchard Brand and Mechling trade-marks.

The period 1918-44 saw a steady growth in the Baker & Adamson Division. In addition to the strictly reagent business developed with educational, research, and industrial laboratories, the B. & A. Division met the growing demands for high-purity special grades of chemicals used in many industries. "B. & A." also puts into small-scale manufacture new products (both organic and inorganic) developed by the Company's Research Department. Continuous growth brought expansion of plant and in 1944 a new site was acquired along the Pennsylvania R.R. at Marcus Hook, Pa.

Successful development of a process for the manufacture of anhydrous hydrofluoric acid on a commercial basis and feasibility of commercial production of elemental fluorine resulted in the rapid development of fluorine chemistry. General's early work included development of alkali fluorides and fluoborates for use in metallurgy, especially as a purifying flux in aluminum and magnesium. Subsequently, a series of metal fluoborates was developed for electroplating bearings, largely used in airplane and other gas engines during the war. Boron trifluoride was developed as a catalyst for alkylation and polymerization reactions. Another important result of General's subsequent research was the Genetrons, a series of aliphatic fluorine compounds useful as aerosol dispersants, refrigerants, and for the preparation of polymeric materials containing fluorine.

GENERAL DYESTUFF CORPORATION is exclusive sales agent for dyestuffs, detergents, and auxiliary specialties manufactured by the General Aniline Works Division of the General Aniline & Film Corp. It also distributes numerous dyes produced by other American manufacturers. Although the Company was not incorporated until July 1, 1925, its origin dates back to 1870, when its most prominent founder, Adolph Kuttroff, then 24 years old, imported fuchsin and other dyes manufactured by A. Poirrier of France, and that same year became agent for Badische Anilin und Soda Fabrik, for the sale of alizarin patented in the U.S.A. in 1869. Before World War I the other German producers of dyes—Bayer, Hoechst, Cassella, Berlin, Griesheim, etc.—each had their representative in this country, and all participated in the rapidly increasing business in this country's market for synthetic dyestuffs. Although an abortive effort was made in 1905-7 to consolidate two of these American agencies, the outbreak of World War I found the business divided among the various representatives of several foreign producers.

Prominent among the earliest American producers, though small in output, was Bayer's Hudson River Aniline Works in Rensselaer, N. Y. Following World War I, Grasselli purchased the Rensselaer plant and erected another plant at Linden, N. J. In 1924 all its dyestuff interests were vested in a new company, the Grasselli Dyestuff Corp., which operated these two plants and also distributed Bayer products in America. This company had its own technical and sales organizations, but when General Dyestuff Corp. was formed it took over sales for the Grasselli Dyestuff Corp., which continued only as a manufacturer. Later these plants were acquired from Grasselli by the newly incorporated General Aniline Works which operated early as a manufacturer and had General Dystuff Corp. as its exclusive

sales agent. Both plants have since been tremendously enlarged and today represent a productive capacity well in line with the foremost manufacturers of dyestuffs in this country.

In 1924 H. A. Metz, as Hoechst representative in the U.S.A., learned of the imminent merger of the most important German producers. He advocated a similar consolidation of their American sales agencies. This act was a purely voluntary one and the General Dyestuff Corp. resulted. The merger brought together the domestic assets, franchises, and trained personnel, as well as inventories of H. A. Metz & Co., Central Dyestuffs & Chemical Co., Kuttroff, Pickhardt & Co., and the Sales Division of Grasselli Dyestuff Corp. Among the other assets acquired were American selling rights of the most prominent German dyestuff manufacturers before and after they were merged in the newly formed I.G. Farbenindustrie. For further data on the formation of his new company, see Vol. IV, pp. 233-6.

Adolph Kuttroff was named chairman of the board of General Dyestuff; H. A. Metz became its president; Ernest K. Halbach, secretary-general manager. In 1930, following the death of Kuttroff, Metz succeeded him as chairman and Halbach became president. Halbach had joined the Boston branch of Kuttroff, Pickhardt & Co. in Sept. 1899. Thereafter he worked as salesman in New York and Philadelphia, in 1918 becoming manager of the Philadelphia branch, and in 1923, general sales manager. Eventually, Halbach succeeded Kuttroff as the recognized dean of the dyestuff industry. The General Dyestuff Corp. prospered and grew under a president and associates who have made dyestuffs their life's work.

General Dyestuff Corp. became the distributor in the United States of the dyestuffs and textile specialties manufactured by the I.G. Farbenindustrie in Germany and was also the sole agent for similar lines produced domestically by the General Aniline Works, which it supplemented with purchases from other concerns on a more or less exclusive basis. In this manner it acquired the most comprehensive range of dyes available to any one concern in his country. Whereas it obtained a substantial share of the highly competitive tonnage business in the so-called commercial colors, its chief interest lay in the cultivation of the American market for the quality products comprising the latest dyestuff developments in this country and abroad. In pursuit of this end it organized the largest staff of dye technicians of any American firm, through whose laboratory studies and mill trials new high levels of perfection in dye application were achieved.

By 1936 General Dyestuff had outlived its second executive headquarters and built a new home, which was thought would always provide adequate facilities, but which will probably require expansion in the near future. It is a nine-story building with 250,000 sq. ft. of floor space, located at 435 Hudson St., N. Y. City. Every floor was functionally designed from the upper story, devoted to a complete application laboratory, to the other floors, comprising executive and clerical offices and facilities for storage, mixing, and shipping. Adequate quarters were also provided the branch offices at 123 S. 2nd St., Philadelphia, and 251-5 Atlantic Ave., Boston. In 1940 an impressive building in landscaped grounds, with its own railroad siding and excellent trucking facilities, was erected on the outskirts of Charlotte, N. C. Sales offices and warehouses are also located at Providence, Chicago, and San Francisco.

Although importation of German dyes was resumed after World War I, and received a considerable impetus through the operation of the Textile Alliance, a government-sponsored enterprise for the distribution of reparation dyestuffs, it never regained its former value. Naturally, these importations ended when World War II broke out. In July 1942 the stock of General Dyestuff Corp. was vested by the Government, although all the shareholders were American citizens and the

majority of the stock was the property of native Americans. In Jan. 1945 the Government purchased, for cash, this stock to retain control of the Company, but the management remained unchanged.

Imported dyes were economically limited to those which the home industry could not supply. Heavy duties made foreign dyes expensive, but their quality justified their use in a highly competitive market. They were furthermore needed to compete with foreign textiles containing them, which were making a strong bid for our market. General Dyestuff performed a true service to the home industry in making available the latest patented discoveries in the dyestuff field, without which it would have had to enter the highly competitive period of the thirties. German-made specialties were systematically duplicated in this country by the efforts of the General Dyestuff Corp. No time was lost while awaiting the lapsing of foreign patents. As quickly as any given product established its importance in the American market, its manufacture in this country was undertaken. Accordingly, when World War II broke out imports of German-made dyes had declined to only 3% of all the dyes consumed in this country. The domestic manufacture of products hitherto imported was accelerated, but this was merely the culmination of a long program in effect since the organization of the Company.

When it became evident that this country must inevitably participate in another World War, General Dyestuff made a careful survey of industry's probable war requirements and in cooperation with General Aniline Works outlined a new manufacturing program. In cooperation with the War Production Board, through its representation on the Industry Advisory Committee, the Company's contribution to the war effort evoked from General Somervell the statement, "Your company has played a very important part in producing the equipment and supplies which have been such a decisive factor in winning the war." These included: a complete range of fast dyes for combat uniforms, camouflage fabrics, mosquito netting, blankets, etc.; enormous quantities of dyes to war production plants, assuring uninterrupted completion of their war contracts; development and large-scale manufacture of special dyes for coloring smoke from bombs, flares, and grenades; quick process for dyeing navy uniform cloth in ordinary dyehouse equipment, based on indigo leuco ester; mosquito and insect netting dyed, made water-repellent and mildew-resistant in one operation; fast colors on nylon for parachutes, harnesses, and other military uses; a radically new process for reel dyeing of vat colors on underwear; use of metallized dyes (Palatine fast colors) whereby the required fastness on woolen fabrics was obtained in a short process with smaller amounts of critically short chrome (required for munitions); development of colors for protective clothing against gas attack, compatible with the emulsions for treating these uniforms and requiring the use of vat pigments, rather than the customary mode of application.

Postwar, these and later achievements assure volume production of fast colors on cotton at costs approaching those of more fugitive "direct" dyes, lower dyeing costs for fast colors on wool, many fast shades on nylon; flameproofed, mothproofed, mildewproofed, and water-repellent fabric; efficient laundering in hard or sea water; elimination of slime in paper mills and prolongation of the life of paper felts. The application research of General Dyestuff technicians covers the entire field of dye consumption. New or improved processes are now available for many trades besides the textile.

GENERAL ELECTRIC COMPANY and its predecessor companies have been in the chemical business from their beginning. The roots sprang from a patent issued to Thomas A. Edison in Jan. 1880, for an electric lamp consisting of a high-resistance carbon filament in a sealed glass container. From these grew a tangle of legal complications over carbon, and had it not been for the resulting litigation, the Company might not have been established.

Edison began to warn competitors as early as 1882 that they were infringing upon his patent. Some contended that the invention had been anticipated; others, that it had previously been done. In June 1886 the court battle began, and the trial which started Oct. 15, 1889, lasted many months. The storm center was the light-giving element of the lamp which Edison called the filament. Other inventors employed carbon sticks or "rods," which differed from Edison's "thread" filament only in diameter. Edison's method was to knead lampblack and coal tar into the consistency of putty. This product was then rolled out upon a plate of ground glass to the hairlike or filament diameter of from .006-.017 of an inch. Short pieces were cut off, wound upon a wooden mandrel into a spiral form, carbonized, and sealed into vacuous bulbs. On July 14, 1891, the court decided in favor of Edison, maintaining that a carbon rod is not the same as a carbon thread. Legal triumph meant immediate commercial triumph. But the patent would expire in 1894! So even in the face of victory the future was not bright and thoughts of consolidation became more numerous in both camps.

In many larger American cities in 1892 two rival electric lighting systems existed. One local company exploited the Edison low-tension direct-current method of incandescent illumination, the other operated the Thomson-Houston Co.'s (established at Lynn, Mass., 1883) high-tension alternating-current arc-lighting circuits and series incandescent circuits. The two systems belonged together, yet no plant could be constructed and no system installed by either company without infringing upon the other's rights. Therefore consolidation formalities were completed and on June 1, 1892, General Electric began to operate in its own name. Since then chemical and electrical research and progress have gone hand in hand.

Since 1900, when Dr. Willis R. Whitney, a colloid research chemist at M.I.T., was brought to Schenectady to establish a research laboratory, the first such industrial laboratory in the nation, G.E. has maintained a program of basic chemical research to parallel its manufacturing. The work of that laboratory, started in a barn and soon to occupy a new $10,000,000 home on the Mohawk near that city, would furnish material for several volumes. In this brief account are recorded only some highlights leading to the establishment in Jan. 1945 of the Chemical Department of General Electric.

One of the early problems to which Dr. Whitney contributed was an improvement in the life of carbon-filament lamps through high-temperature, high-vacuum treatment of the filament. The graphitized carbon brush is an extension of this discovery. This work was followed in 1908 by the important contribution on ductile tungsten made by Dr. W. D. Coolidge, later Dr. Whitney's successor as director of G.E.'s Research Laboratory. His "powder metallurgy" technique led to such diverse products as porous bearings, copper-tungsten electrodes, cemented tungsten carbide tool stock, permanent magnets of sintered aluminum-nickel-cobalt-iron alloys (Alnico), and nickel-molybdenum and nickel-tungsten alloys for thermocouples.

Another G.E. scientist and Nobel prize winner, Dr. Irving Langmuir, has made fundamental contributions to chemistry. First recognized for his work on atomic structure, Dr. Langmuir's classic investigations into the nature of chemical reac-

tions and physical processes at low pressure have led to such practical ends as the high-vacuum mercury pump, the gas-filled lamp, and various types of radio and power vacuum tubes. His later extensive studies of surface phenomena have had practical applications in atomic hydrogen welding, "invisible glass," highly improved gas masks, smoke generators (adapted almost exclusively by the Army Engineering Corps and by Navy Ordnance during World War II), de-icing of high-altitude flying equipment, and recently, the artificial nucleation of cloud formations.

In general. most G.E. contributions to chemical knowledge have started with illumination, insulation, and protective-coating problems. But continued research and new applications have led into chemical activities not ordinarily associated with electrical manufacturing. Plastics is an example. General Electric began activity in this field in 1893 when it started molding carbon rods for arc lamps from clay and lampblack. Although a predominance of the thousands of G.E. plastics items now made are closely allied to the control of electricity, a considerable portion is not. Today the Company is the world's largest molder of plastics, a leader in the manufacture of laminated materials, and a substantial factor in the manufacture of chemicals, resins, and plastics raw materials.

Another example of G.E. excursions into chemistry is insulation materials. In 1892 the Stanley Co. at Pittsfield, Mass. (purchased by G.E. in 1903), was insulating transformer coils, first by treated cotton cloth and later by impregnating with a compound so that wires and compound formed a solid mass. Since then, through the Research Laboratory at Schenectady and the various plant laboratories, a steady stream of improved insulation materials has emerged—insulating varnishes, tapes, cloth, synthetic rubber, adhesives, paints, and lacquers.

Before 1900 the Company was molding, in addition to carbon products, shellac, hard rubber, copal, and other natural resins to provide insulation parts for electrical apparatus. At or near the turn of the century it started to manufacture insulating varnishes and finishes.

In 1912 G.E. began manufacturing molded and laminated products of phenol-formaldehyde synthetic resins. That year, research of polyester resins of the glyceryl phthalate type (Glyptal) was initiated through the foresight of A. McK. Gifford, head of the Pittsfield Works Laboratory. Manufacture of these resins began at Pittsfield, on July 20, 1914. They were first used in lightning arrestors about 1921, and partly replaced shellac as a bonding medium for mica in 1926. Glyptal alkyd resins have since been used for coating transformer coils, refrigerators, and other appliances, and for many other applications. Their production and sale during the last 15 years have increased a hundredfold. In 1947 a plant was opened at Anaheim, Calif., for their manufacture on the West Coast.

The Company not only pioneered in the use of these glyceryl phthalate resins, but was first to produce low-acid types, light colors. color retentive vehicles, refrigerator finishes, quick-drying red primers, traffic zone paints, architectural enamels, and marine paints. For two decades after 1893, G.E. expanded its molding plastics activities and soon after Dr. Leo Baekeland took out patents in 1909 for phenol-formaldehyde resin, was molding phenolic plastics, which led to laminated phenolic plastics. By the middle twenties, it was producing plastics for insulation and for mechanical purposes such as industrial gears for the quiet transmisison of power.

On Dec. 23, 1930, all plastics activities of the Company were consolidated into a separate, decentralized unit, the Plastics Department, with offices in Boston, New York, Philadelphia, Cleveland, Detroit, and Chicago, and headquarters at Lynn. Manufacturing plants were located at Pittsfield and Meriden. In addition, the

molding plant at Fort Wayne was operated by the Department to take care of Midwestern business. For the manufacture of laminated products, the Department operated the Fabroil and Textolite gear-manufacturing plant at River Works, Lynn. The Schenectady Works manufactured the laminated phenolic insulating materials, which the Plastics Department sold until the fall of 1932, when these manufacturing facilities were transferred to the River Works.

May 1, 1936, the Plastics Department was reorganized, the engineering, manufacturing, and internal distribution of plastics within the Company being assigned to the manager of the Plastics Department, and the commercial activities to the Construction Materials Division of the Appliance & Merchandise Department. In June 1936, sales headquarters were moved to Bridgeport, Conn., and the operation of the Fort Wayne molding plant was taken over by the Plastics Department. The sales organization remained in Bridgeport for about a year and then was transferred back to the Plastics Department, with headquarters at Pittsfield.

The first G.E. injection molding press was brought from Germany about this time, and the Company began manufacturing plastic products from thermoplastic resins. There were many new plastics operations in 1941. A new plant was established in Taunton, Mass.; injection molding of G.E. Mycalex, a stone-like product composed of ground mica and a special glass, was begun (G.E. had been producing Mycalex parts by other methods for two decades); and a phenol plant constructed at Pittsfield. Late in 1944 the engineering, manufacturing, and sales units of the Company concerned with insulation materials were combined to form a division of the Appliance & Merchandise Department, to which the newly developed silicone products were entrusted.

About 1904 Professor Kipping prepared in England the first organo-silicon compounds. As his research was directed to the isolation of pure compounds, he apparently did not realize or investigate the importance of these resinous products. However, he and his associates published over 50 papers dealing with silicon chemistry. A number of years ago, an active research and development program in the silicone resin field was started in the Research Laboratory of General Electric. World War II gave great impetus to that program because of the importance to the war effort of the new silicone products—water-repellent films, oils, greases, resins, and rubber.

On Jan. 1, 1945, the insulation and plastics operations of the Company were united to form a new operating unit—the Chemical Department. Dr. Zay Jeffries was put in charge and elected vice-president of G.E., with headquarters in Pittsfield. The Department has four major divisions: Resin & Insulation Materials and Metallurgy Division, headquarters in Schenectady; Plastics and Compound Divisions, headquarters in Pittsfield. A new plant in Waterford, N. Y., houses the silicone operations. The Plastics Division at present is operating plants in Pittsfield and Taunton, Mass., Meriden, Conn., Scranton Pa., Coshocton, O., and Decatur, Ill.

Sept. 1, 1946, General Electric took over the management of the Hanford Engineer Works, one of the three major units of the Manhattan Project which produces fissionable materials, the project covering over 600 square miles. The Company, at the request of the Army, took over the management of Hanford from E. I. du Pont de Nemours & Co. which built the plutonium plant and agreed to operate it only until the end of the war. General Electric is operating the works for the Government on the basis of cost plus a fee of one dollar. Final authority over Hanford for the present rests with the Atomic Energy Commission.

When the Chemical Department was established, its objectives were to engage in the manufacture and sale of chemical products especially useful in the electrical

industry and to exploit the chemical developments made by the Company, including such by-products as are natural to these activities.

GLIDDEN COMPANY was founded by Adrian D. Joyce in 1917, with himself as president; O. A. Hasse, vice-president; R. H. Horsburgh, secretary-treasurer; and a board of directors comprised of these three plus Sam H. Moore, James H. Dempsey, C. F. Hackathorn, and Herbert K. Oakes. It was Joyce's idea to so locate the factories geographically that freight rates would be competitive and the whole country could be served. The Company was incorporated in Ohio, on Dec. 11, 1917, with its principal office at 1396 Union Commerce Bldg., Cleveland.

At its formation, the Company acquired the business and assets of the Glidden Varnish Co. of Cleveland, manufacturers of industrial varnishes and "Japalac" varnish stains, founded in 1895. In 1919 it purchased 11 other manufacturers and distributors of paints, varnishes, dry colors, kalsomines, and allied products, together with their brands and good will: Adams & Elting Co., Chicago; American Paint Works, New Orleans; T. L. Blood & Co., St. Paul; Campbell Paint & Varnish Co., St. Louis; Forest City Paint & Varnish Co., Cleveland; Heath & Milligan Manufacturing Co., Chicago; Nubian Paint & Varnish Co., Chicago; Whittier Coburn Co., San Francisco; Twin City Varnish Co., Minneapolis; and A. Wilhelm Co., Reading, Pa.

The Company and its subsidiaries operate under eight principal divisions: Paint & Varnish, the oldest; Chemical & Pigment; Metals Refining; Naval Stores; Vegetable Oil; Food Products; Soya Products; and Feed Mill. There are eight strategically situated paint and varnish factories, and the Glidden Co., Ltd., a wholly owned subsidiary, owns and operates a paint and varnish factory at Toronto, Canada. Products are distributed generally through jobbers and dealers and 30 retail stores and six warehouses are maintained. Finishes for industrial, railway, and general maintenance purposes are sold direct through specially trained salesmen. Since 1919 lacquers and other types of finishes have been added so that the Company now manufactures and sells coatings of practically every type for decorating and preserving surfaces.

The Chemical & Pigment Division was started in 1921 when the Company incorporated the Chemical & Pigment Co., Inc., as a wholly owned subsidiary. This subsidiary manufactured lithopone and developed nonfading furnaced pigments known as cadmium yellows and cadmium and selenium reds, which are sold to the paint and ceramic industries, to manufacturers of printing inks, to outdoor advertisers, for railway signal purposes, and for automobile finishes. It also produces ground white barytes for the paint and rubber trade, and zinc sulfate crystals for fertilizers and fungicides. On Jan. 1, 1936, Glidden merged this subsidiary as a part of its Chemical & Pigment Division.

Manufacture of white lead carbonate and white lead in oil came in 1924 through the acquisition of the Euston Lead Co. of Scranton, Pa.; manufacture of red lead, litharge, type metal, metal powders, cuprous oxide, white metal alloys, and other allied products, in 1929 through the purchase of the Metals Refining Co. of Hammond, Ind. These companies were operated as wholly owned subsidiaries until Jan. 1, 1936, when they became part of the Chemical & Pigment Division. In 1933 the Company organized the American Zirconium Corp. to produce titanium pigments, took over its assets in 1944, and now operates it under the Chemical & Pigment Division, manufacturing titanium dioxide under the trade name of Zopaque.

In 1938 the Company acquired the assets of the Southern Pine Chemical Co., engaged in the destructive distillation of pine wood and manufacturing Pigmentar

for the rubber trade, wood turpentine, pine tar oil, charcoal, etc. Aug. 1940 Glidden incorporated the Nelio Resin Processing Corp. to manufacture by a patented process Nelio Resin, as well as turpentine and rosin. This company was subsequently combined with the Southern Pine Chemical Co. under the supervision of the Naval Stores Division, which operates plants at Jacksonville, Fla., and Valdosta, Ga.

In 1938 the Liberty Vegetable Oil Co. at Buena Park, Cal., was acquired and now operates as Glidden's Vegetable Oil Division which produces crude vegetable oils from oil-bearing nuts, copra, and flaxseed. The Company constructed a plant at Chicago for processing soybeans and extracting the oil, in 1934. Besides oil, meal, and flour, this plant produces Alpha-Protein, Prosein, lecithin, and pharmaceutical hormones from soybeans. In 1942 Glidden acquired the property formerly owned by Standard Cereals, Inc., at Indianapolis, and began manufacturing poultry and cattle feeds, utilizing certain by-products from the Soya Products Division and other sources. This operation is now under the Feed Mill Division.

The Glidden Food Products Co. was incorporated in 1920 as a wholly owned subsidiary, to refine vegetable oils and manufacture oleomargarines, plastic and hard butters, and hydrogenated oil fillings for the pastry and baking trades. In 1929 this subsidiary acquired E. R. Durkee & Co., changed the name to Durkee Famous Foods, Inc., and expanded operations to include production of coconut and sesame oils, refining of edible vegetable oils, and manufacture of various food products. This subsidary became a division of the Company, Jan. 1, 1936. The Company is also engaged in the manufacture and marketing of spices and condiments. In 1933 Glidden acquired a vegetable oil refinery and shortening manufacturing plant at Louisville, Ky., and thereby entered the business of refining cottonseed oil, manufacturing cottonseed oil shortenings, and producing salad oils. Its Food Products Division operates seven manufacturing plants located in Elmhurst, Long Island, N. Y.; Norwalk, O.; Chicago (2); Louisville, Ky.; Portland, Ore., and Berkeley, Calif.

In 1947 the Company joined with the Phelps Dodge Refining Corp. and the International Minerals & Metals Corp. in organizing the Zinc Chemical Co., for the utilization of zinc residues and manufacture of zinc sulfate crystals at St. Helena, Md. Also that year it joined with the Wallace M. Quinn Fisheries in the organization of Growth Products Co. for the production of fish products for feeds, at a plant in Pascagoula, Miss.

The Company now operates 35 factories and 26 research and control laboratories. Its principal products include foods, soybean products, paints, vegetable oils, chemicals and pigments (titanium dioxide, lithopone, cadmium colors, litharge, red lead, Euston white lead, cuprous oxide, zinc sulfate crystals, dry colors), metals and minerals (powdered iron and copper, powdered lead and tin, Glidden type metal), and naval stores (tars and resins, turpentine, solvents, synthetic rubber compounds, compounds for plastics).

Jan. 1947, Adrian D. Joyce, president since 1917, was elected chairman and chief executive officer, and R. H. Horsburgh became vice-chairman. Dwight P. Joyce was elected president; P. E. Sprague, W. J. O'Brien, Newell Beatty, Alexander D. Duncan, and L. Y. Pulliam, vice-presidents; John A. Peters, treasurer; and Clifton M. Kolb, secretary. Other board members are Dwight P. Joyce, O'Brien, Sprague, Peters, Kolb, Pulliam, John P. Ruth, Duncan, and N. B. Betzold.

B. F. GOODRICH COMPANY has a chemical phase directly responsible for its role in the rubber, plastics, and chemical industries. At Akron, O., a partnership—Goodrich, Tew & Co.—was founded by Dr. Benjamin F. Goodrich, Harvey W. Tew, Henry S. Sanderson, Robert Newland, and David N. Marvin,

Dec. 31, 1870, which was succeeded in 1874 by B. F. Goodrich & Co., and in 1880 by B. F. Goodrich Co. (Ohio), incorporated with a capital of $100,000 by B. F. Goodrich, Geo. T. Perkins, Geo. W. Crouse, Alanson Work, and Richard P. Marvin, Jr., who constituted the first board of directors. In the present corporation—B. F. Goodrich Co. (New York)—capitalized after the merger (1912) with Diamond Rubber Co. at $90,000,000, the present chairman, David M. Goodrich, is the son of the founder.

Dr. Goodrich's interest in surgery, which he had practiced as an officer during the Civil War, prompted him to manufacture a line of surgical appliances and to renew his acquaintance with Western Reserve Medical School in Cleveland from which he graduated in 1861. Tradition has it that he consulted with the dean, Dr. John L. Cassels, on chemical problems which arose in the manufacture of rubber goods. Charles Goodrich, his son, a Harvard graduate with courses in chemistry, became manager of the laboratory in 1895. He later succeeded Bertram G. Work as general superintendent, a position he held when he left the Company in 1907. During his service two graduates in chemistry from Buchtel College (University of Akron), Arthur Warner (1903) and John Thomas (1905) were added to the staff. Both later became widely known in rubber circles. Warner has said that the varied problems which came to the laboratory at this time were mainly practical studies in rubber compounding. Thomas has recently retired as chairman of the Firestone Tire & Rubber Co.

In 1907 Dr. W. C. Geer was employed as manager of the laboratory, which he organized along systematic lines for testing, compounding, development, and research. One of the keenest competitors was the Diamond Rubber Co., with laboratories just across the street. Diamond had been incorporated Mar. 23, 1894, with capital of $50,000. By 1900 Diamond's technical problems were under Arthur H. Marks, inventor of the alkali reclaiming process, and Alkali Rubber Co., organized jointly by the Diamond and Goodrich (1904), controlled Marks' patents and made and sold products under them. Marks brought his former teacher at Harvard, Dr. Joseph Terrey, to Akron as research chemist with Diamond from 1900 to 1903. In 1905 he brought in George Oenslager and set him to work on rubber accelerators. In Marks' vision, the chemicals he expected to derive from the Oenslager work were of the highest strategic importance. Oenslager used aniline and its offspring thiocarbanilide. Both had the magic touch, but thiocarbanilide was preferred in practice. They made it possible for Diamond to supply rubbers at an advantage of $20,000 a day over competition. Oenslager's early work, like all industrial research at that time, was shrouded in trade secrecy. The aniline was first imported from Germany. As the quantities required for accelerators grew larger, it was decided to manufacture aniline at Diamond, starting from benzene as a noninformative source, since it was largely used as a solvent for rubber cements. This was one of the earliest installations of aniline manufacture in America. Production actually started Jan. 1916, by March rose to 3,000 lb. per day, and was stabilized later in the year at 2,000 lb. per day. Another early chemical engineering project of Oenslager's at Diamond was the recovery of gasoline from the solvents used in making extracted rubber and from the petrolic ether or rock oil, then imported from Scotland, used in the purification of balata. Gasoline was thus recovered in 1907. Nonvolatile petroleum oil was used as the absorbent medium and volatile vapors of gasoline were released therefrom by subsequent heating.

The success of Marks' venture justified his investment in research. Between 1910-14 the staff, consisting of David Spence, G. D. Kratz, John Young, W. F. Zimmerli, Geo. Carruthers, Wm. F. Russell, J. C. Calletly, A. P. Clark, James H.

Scott and others, covered a wide field requiring 23 volumes of notes and reports to record. Of greatest moment was Dr. Spence's discovery that *p*-aminodimethylaniline conferred on cured products not only superlative physical properties but good aging attributes as well. This accelerator, despite its high cost (over $3 lb.), was used in large tonnages more than 10 years. These research men also made isoprene, and other dienes, such as 2,4-dimethylpentadiene, and conducted numerous experiments to make synthetic rubbers. The Hood Rubber Co. of Boston (now Hood Division, B. F. Goodrich) early displayed deep interest in the scientific and technical phases of rubber. In 1904 it engaged Carl O. Weber, author of the then-authoritative text on rubber, and during 1910-14 supported the research of R. B. Earle and L. P. Kyrides, which resulted in the manufacture of a diene-type synthetic rubber used in rubber footwear.

In 1912 the merger of Diamond and Goodrich resulted in B. F. Goodrich Co. (New York), with B. G. Work, president, and A. H. Marks, vice-president. Research and development continued in segregated units; the staffs under Marks' direction remained in the Diamond laboratory. The Goodrich laboratory under Dr. W. C. Geer had grown steadily. In 1909 J. W. Schade was hired as chemist and compounder in the pioneer laboratory initiated by Charles Goodrich. At this time R. R. Olin had charge of physical testing; August Venner headed the milling and curing laboratory; in the chemical laboratory were John Link and John Moriarty. In 1910 the laboratory was moved to better-equipped new quarters and in 1911 Dr. Geer hired W. W. Evans as research chemist. Not until 1919 were the two laboratories consolidated.

The demand for accelerators and for deresinated bastard gums made it necessary that Diamond build a plant in a remote location for chemical processes. A unit designated Plant #3 was built and came under the supervision of F. Peabody and later under A. B. Jones, a Goodrich vice-president. By 1919 Plant #3 was operating the methylation of aniline to dimethylaniline; the preparation of *p*-nitrosodimethylaniline, its reduction to *p*-aminodimethylaniline and purification; manufacture of accelerator rubber #11, by hanging sheets of crepe or smoked sheet in aqueous solutions of *p*-aminodimethylaniline and drying these in vacuum shelf driers; the formaldehyde condensation product of this base; and the extraction of cinchona bark to give a mixture of alkaloids, which found favor as an accelerator. Occasionally batches of extracted (deresinated) wild rubbers were made, but more pertinent, there accumulated a small mountain of the resins from guayule and other high-resin rubbers. For years nothing was done with this stockpile, then Geo. Sherman, Akron Salvage Co., made it available to paint manufacturers and to makers of sticky flypaper. As a result of the World War I shortages of rubber softeners, the compounders at Goodrich went to the mountain for Mariola resin, only to find that the bog had engulfed half of the stock and the resin had to be removed by excavation. In 1919 this Mariola mine was the main source of softeners for rubber used in tires.

Plant #3 was equipped as a modern chemical factory in 1919, when J. R. Silver, Jr., former Major, Chemical Warfare Service, became superintendent. Succeeding Silver were T. Atkins and Ray Albright, and for the last 20 years, William I. Burt, vice-president in charge of manufacturing, B. F. Goodrich Chemical Co. (1946). In three decades Plant #3 has witnessed the advent of: xanthates, aldehyde-amine condensation products, thermoprene of various grades but mainly for Vulcalock, age resistors (Resin, Resin D, Powder, White, Excel, Iso, and Alba, the whole tribe of Age-Rites for rubber), vinyl chloride, its polymers and copolymers, which gave Koroseal products to the world, adaptations of Koroseal such as Korogel, and the proofing of fabrics. About 1930 Plant #3 housed the pioneer

factory in the United States for making rubber goods by the anode process, with facilities for both ionic coagulation and electrodeposition. Since 1940 the Hycar rubbers have been made in a factory of 10,000 tons per year capacity, located at this plant.

Plans were made during World War I for expanded research along chemical lines. In 1918 Dr. Benton S. Dales came to work in inorganic and colloidal chemistry. Upon completion of the expanded research laboratory, 1919, work was organized in five groups as follows, chemical: (1) George Oenslager, Benton Dales, J. S. Howard, Alexander Mirkin, Fred Amon, (2) Harry L. Fisher, Herbert Winkelmann, Harold Gray, (3) Harlan Trumbull, Henry C. Howard, Webster N. Jones, (4) John B. Dickson, John Rollins; and physical: (5) Hiram Ayres, Ernest O. Dietrich, Clayton Housel. Scarcely were the projects launched than they were interrupted by severe economic chaos which continued until 1922. Then C. W. Bedford was added to activate the program on accelerators. For the next several years Harry Fisher researched derivatives of rubber and produced the thermoprene isomers. Dr. Geer discovered the use of thermoprene as an adhesive, bonding rubber to metal, the "Vulcalock" process. A line of novel rubber-lined and rubber-covered products was introduced by Howard E. Fritz, vice-president in charge of research, B. F. Goodrich Co. (1946), who joined the Company in 1925. The influence of Dr. Fritz in bringing the laboratory closer to the Sales and Production Departments and in convincing the management that research be expanded, stands as a bright chapter in the research development of the Company. Richard A. Crawford, Edwin Newton, Waldo Semon, and A. W. Sloan were added to the research staff in 1926. These men discovered new rubber compositions, high polymers, age resistors, and latex techniques.

In 1922 Harlan L. Trumbull and John B. Dickson discovered the process of making artificial dispersions of rubber in water, the first step in latex developments that culminated in American Anode, Inc. (1936), with a staff of competent scientists—Henry C. Howard, Jr., Carl Beal, Andrew Szegvari, Edwin Newton, Edward Willson, C. C. Curtis, Benton Dales, Tom Dodds and Harold Meyer. Rubber and reclaim dispersions were first handled by Crawford about 1925. In 1926-27 Semon and Sloan initiated detailed study of age resistors, explored earlier by W. N. Jones (1920) and by Harold Gray and Herbert Winkelmann (1922-23). In 1927 B. S. Garvey and Paul Jones were assigned to the same field, which started with David Spence's accelerator, running through Geer and Evans' aging oven (1917), Winkelmann and Gray's nonaccelerating age resistors, and culminating in protective chemicals to which was attributed (1929) an annual saving to motorists of $50,000,000.

In 1926 Dr. Semon initiated experiments on the synthesis of high polymers leading both to the elastic and plastic types, work continued by Garvey who patented thermosetting polymers, and to the manufacture of vinyl polymers, Koroseal and Geon, by E. B. Newton, S. L. Brous, and Dr. F. K. Schoenfeld, vice-president (technical), B. F. Goodrich Chemical Co. (1946). Semon's early work also led to the Ameripol tire which dramatically emphasized the need for American-made rubbers. In 1926 he had centered work on polyvinyl chloride, discovering that although insoluble at room temperatures, this chloride could be dissolved in certain nonvolatile liquids at high temperatures, and when cooled, become a rubbery solid. During 1931 the name Koroseal was coined as the trade-mark for polyvinyl chloride products. In the years immediately preceding World War II, a wide variety of products was made from plasticized polyvinyl chloride and met with such tremendous success that it became necessary to construct commercial polyvinyl chloride plants at Niagara Falls in 1940, followed by a larger plant at Louisville in 1942.

Early 1940, the Hydrocarbon Chemical & Rubber Co. was formed with the Phillips Petroleum Co. to market synthetic rubbers developed in the Goodrich research laboratories and made in a portion of Plant #3, operated by Goodrich personnel. The contribution of Phillips was mainly a source of butadiene, not then commercially available. In early 1942 the name was changed to the Hycar Chemical Co. In Dec. 1945 the Goodrich-Phillips partnership was dissolved, with Goodrich assuming all physical assets, trade names, and good will of Hycar. The operation of the Hycar plant was then assigned to B. F. Goodrich Chemical Co. Present Hycar American rubbers are copolymers of acrylonitrile or styrene with butadiene, all made by emulsion polymerization.

In 1941 the Chemical Division of the B. F. Goodrich Co. had been organized for the sale of polyvinyl chloride resins and plastics in the raw form. In Nov. 1943 the Chemical Division was expanded to include all functions of a separate company unit with its own manufacturing, technical, and sales departments; it moved to Cleveland, July 1944. A completely equipped sales-service laboratory was constructed adjacent to the sales office. During World War II, the Chemical Division, and later the Chemical Co., devoted its entire effort to war production.

Apr. 1945, John L. Collyer, president, announced the B. F. Goodrich Chemical Co., naming W. S. Richardson president. This new company, a division of the B. F. Goodrich Co., assumed all the functions associated previously with the Chemical Division, and Jan. 1, 1946, J. R. Hoover was appointed vice-president, sales, and the following March, F. K. Schoenfeld was appointed vice-president, technical, and Wm. I. Burt, vice-president, manufacturing.

The summer of 1946 saw the opening of the Avon Lake Experimental Station, a unit designed to handle operations classified under the terminology of development laboratories, pilot plants, and semiworks units. The Avon Lake station symbolizes the growth of Goodrich chemical operations, for a similar unit has been functioning at Plant #3 in Akron over 10 years. The work load is now divided between these two stations, with Avon assuming chemical and some resin development work and Akron carrying on the rubber development operations. The Avon station is now under the direction of H. B. Warner, while Dr. B. M. G. Zwicker is in charge at Akron.

Goodrich played a leading role in the Government's GR-S (synthetic) rubber program. Pioneering with a private development of synthetic rubber in early 1938, the Company had much of the know-how so necessary after Pearl Harbor. It constructed not only those plants to be operated by the Goodrich Co., but other units producing a total of 225,000 tons of the entire GR-S program of 735,000 tons a year. A Goodrich stripping unit (monomer recovery) was adopted as standard design for all GR-S plants. Goodrich GR-S plants, operated by the Chemical Division and later by the Chemical Co., were located at Louisville, and Borger and Port Neches, Tex. The Louisville plant was opened Nov. 1942, and the other plants in July and Aug. 1943. Actively engaged in setting up the GR-S program were William I. Burt of the Chemical Co. and Arthur Kelly, assistant works manager of B. F. Goodrich in Akron, who acted as consultants. Dr. R. V. Yohe, now president of American Anode Co., Akron, a Goodrich subsidiary, was in charge of the specifications committee of the Office of Rubber Reserve; and W. W. Scull, later production manager of plants for Goodrich Chemical, was chairman of the GR-S purchasing committee. Jan. 15, 1947, W. S. Richardson announced that a total of 500,000 long tons of American rubber had been turned out by the Chemical Co. since 1942, the greatest quantity turned out by a single producer for the Government.

B. F. Goodrich Chemical Co. has expanded since the end of the war. Many

new products have been added. Kriston resin, a new thermosetting allyl ester, was introduced in 1945. A year later the trade name Good-rite was adopted to cover all the rubber chemicals, industrial and agricultural chemicals. A significant announcement, Sept. 1947, was a new organic chemical intermediate, β-propiolactone. This was introduced at the 112th meeting of the American Chemical Society in New York and was described as "another fundamental tool in the complex science of manufacturing organic chemicals. Its use as a basic chemical makes possible for the first time in chemical history the commercial production of whole series of organic chemicals hitherto regarded as laboratory curiosities." Moreover β-propiolactone promises to open up new and cheaper reaction methods of producing many basic materials already used in the chemical and plastics industries. This announcement and the recent entry into the agricultural chemical field are indicative of the progress B. F. Goodrich Chemical Co. has made in the chemical industry.

The $6,000,000 Research Center of the B. F. Goodrich Co., at Brecksville, O., was opened in 1948. Information resulting from basic industrial research work at the Center is passed on to B. F. Goodrich Chemical Co. for commercialization.

GOODYEAR TIRE & RUBBER COMPANY started business in 1898, in a small plant in East Akron. Its first board of directors were also its officers: D. E. Hill, president; G. R. Hill, vice-president; C. W. Seiberling, secretary; H. B. Manton, treasurer; and F. A. Seiberling, general manager.

F. A. Seiberling soon assumed control of the Company and, by his dynamic courage and optimism, guided it through a tremendous expansion until 1920, when he organized the Seiberling Rubber Co. Hard hit by the depression of the early twenties, the Company emerged with renewed vigor under the direction of P. W. Litchfield, who has been its leader ever since. The present officers are: Paul W. Litchfield, chairman; Edwin J. Thomas, president; Robert S. Wilson, Paul E. H. Leroy, Russell De Young, Fred W. Climer, Clifton Slusser, John M. Linforth, and Ray P. Dinsmore, vice-presidents; Z. C. Oseland, treasurer; Wm. D. Shilts, secretary; Charles H. Brook, comptroller; Howard L. Hyde, general counsel and assistant secretary; Wm. M. Mettler, assistant secretary; Howard D. Hoskin, James Caldwell, and Hollis L. Riddle, assistant comptrollers; N. V. Hillman and J. E. Bennett, assistant treasurers.

The manufacture of rubber goods is not out of place in the chemical industry, for vulcanization is a chemical process and catalysts, retarders, antioxidants, and colloidal dispersions are all important factors.

Goodyear started business when automobiles were first being sold, and in 1901, in the first decade of its growth, made two major contributions to the automobile tire: the woven-tape wire bead and the detachable rim. These developments made practical the straight-side tire, a much-needed feature for automobile development. In 1908 the first Development Department in Goodyear was started, with E. R. Hall heading mechanical design and Lyman Bourne, the chemical end. In 1910 Goodyear designed the first practical airplane tire and in 1912 produced successful balloon and airship fabric from rubber compositions.

A milestone in the automobile tire business was the cord tire. Goodyear saw the disadvantages of the large cable-cord idea imported from England, and in 1913 introduced the small-cord, multiple-ply tire, such as is used today. The same year the Company entered the mechanical goods business under the guidance of I. R. Bailey, an old Diamond Rubber man.

In the First World War, Goodyear was active in making blimps, observation balloons, gas masks, and bullet-sealing tanks. In 1916 Goodyear opened a new era

in materials transportation by installing a conveyor belt 735 ft. between centers. This idea progressed with a 4½-mile conveyor in 1923, to the great 9.6-mile conveyor at Shasta Dam in 1938. Also in 1916, Goodyear produced the first pneumatic truck tires and a year later established a cross-country truck line to aid their development.

In 1906 George Oenslager made the epochal discovery at Goodrich that aniline accelerates vulcanization and enhances the final properties of rubber. Then came thiocarbanilide and hexamethylenetetramine, stimulating research to find other materials which would make for better tire performance. At Goodyear, Clayton W. Bedford had made an interesting accelerator from thiocarbanilide and sulfur in a mixture difficult to control. In 1920 Lorin B. Sebrell, now Goodyear's research director, isolated its vital constituent and devised ways of making it commercially pure; a year or two later Wm. J. Kelly worked out a very economical manufacturing process. The new accelerator was named Captax and with the closely-related disulfide, Altax, helped to overcome many problems of rubber compounding. Captax, which proved to be the key to making durable truck-tire compounds, was placed on the market in 1926.

In 1923 Goodyear formed the Goodyear-Zeppelin Corp., now Goodyear Aircraft, to manufacture rigid dirigibles. In 1925 it announced a low-pressure bus tire, the "bus balloon." In 1927 a similar line of tires was made for airplanes, in 1929 for trucks, and in 1931 for passenger cars. These developments added greatly to transportation comfort and economy, but posed many technological problems.

The problem of rapid and uniform vulcanization was only partly solved by Captax. The vulcanization of thick articles was subject to inadequate controls. In the 1920's Goodyear chemists sought to eliminate vulcanization variables. Crude-rubber variations and test methods were examined; likewise process and equipment variables. A most interesting study was the duplication of vulcanization conditions and expression of the result of a given "cure" in terms of its equivalent at a standard temperature. Since rubber is a poor heat conductor, a thick article after heating will vary in temperature from the outer surface to the interior. Combined-sulfur figures were the only means of comparison with a standard laboratory cure until in 1923 Donald F. Cranor of Lee Tire published a method for determining temperature rise in various parts of a tire, by use of embedded thermocouples. At Goodyear, Ralph B. Day and Walter W. Vogt worked out a method for converting the vulcanization effect of a rising temperature curve, to its equivalent at a standard temperature. This method advanced vulcanization control greatly.

After compounds were improved, the outstanding failures in pneumatic truck tires were caused by cord weaknesses. In 1923 Samuel A. Steere developed a compacted, highly-twisted cord, which gave much improved life. In 1928 compounding took another advance step, with the use of zinc oxide in the body and cushion of the truck tire. Then followed a succession of improvements in cord angle, tire shape, flex-point re-enforcement, etc. One of the longest steps in truck-tire heat resistance came about in 1936, as the result of an idea of Ray P. Dinsmore for a rayon cord tire. No suitable rayon was available and a yarn had to be worked out with the rayon manufacturers before twists, adhesives, and other problems pertaining to tire use could be solved. However, performance exceeded all expectations and rayon today is crowding cotton out of the passenger tire as well as truck tire market.

To help clear up the confusion as to the purpose of the numerous accelerators, Dinsmore and Vogt in 1924 issued a classification of all the common accelerators. Sebrell and Vogt demonstrated the need for fatty acids to make many accelerators function. Dinsmore and Zimmerman contributed some new views on "optimum cure." Later, in 1940, John Fielding devised a simple method relating the state of

cure to the set at O°C. In 1928 Vogt devised an angle abrasion machine which DeFrance tested. In 1931 Albertoni described a new autographic tensile tester and in 1937 Fielding showed the correlation between impact resilience and the fundamental properties of carbon black.

In the middle 1920's Dinsmore patented a method for making synthetic rubber by means of a water emulsion, which is significant only in the light of recent commercial methods. Also in the 1920's antioxidants were first used; in 1924 Teppema, at Goodyear, discovered the phenylnaphthylamines, exceptionally cheap and efficient antioxidants.

Spot welding of aluminum alloy was developed by Goodyear in 1929, and the following year asbestos cord steam hose and synthetic rubber gasoline hose were brought out. In 1932 came rubber valves for inner tubes and hydraulic disk brakes for airplanes; in 1933, magnesium-alloy airplane wheels.

Because of cheap rubber in the early thirties, Goodyear developed two rubber derivatives: the chlorinated isomer Pliolite, a good resistant lacquer base; and the hydrochloride Pliofilm, desirable as a protective film. In 1935 Goodyear brought out the "LifeGuard" safety tube, designed by Walter Lee. In 1940 it introduced steel-cable transmission belts; in 1941, steel-cable V-belts; in 1942, steel-cable conveyor belts. In 1942 James C. Merrill received the War Production Board's award for perfecting the bullet-sealing fuel cell for airplanes.

The rapid commercial development of the "Buna" type of synthetic rubber in the Second World War is on outstanding achievement of American industry. The only important improvements contributed by this country, over the German rubbers, were lower cost and better processability. Goodyear built and operated the first government plant for making Buna-type synthetic; it developed an easy processing rubber and devised an economical continuous process. During the war it also built and operated two airplane factories, two powder-bagging plants, an antitank gun plant, a cartridge-loading factory. It operates 11 domestic, and 15 foreign rubber plants, a ranch and prefabricated homes plant in Arizona, a coal mine, an aircraft-parts plant, four textile mills, and three government synthetic plants.

R. W. GREEFF & CO. INC., was established in New York in 1914 as a branch of R. W. Greeff & Co., Ltd., London, founded in 1880 by Robert W. de Greeff, who visualized a promising future for an organization specializing in the distribution of chemical products and was among the first to engage in international trade in chemicals, at a time when the chemical industry was on the threshold of rapid expansion.

Originally R. W. Greeff & Co. confined its activities to England and her colonies. Operations were rapidly expanded, however, to include Continental Europe and the United States. By the early 1890's, de Greeff, recognizing the growing importance of the American chemical industry, began his annual trips to form associations with American manufacturers with the view of handling their sales in foreign markets.

The firm's export business in chemicals produced in the United States, continued to grow rapidly, and by World War I, R. W. Greeff & Co., Ltd., had become one of the largest foreign distributors of American chemicals. At that time, the Company was the largest purchaser of acetone from the Albany Chemical Co., then this country's principal manufacturer; it handled the first shipment of Dow bromides to Europe in 1906. Other American companies whose products were sold in Europe were National Lead Co., General Chemical Co., Grasselli Chemical Co., Wm. S. Gray & Co., Wood Products Co., Cleveland-Cliffs Iron Co., and Minnesota Mining & Manufacturing Co.; the principal American chemicals distributed

included acetone, acetic acid, calcium acetate, methyl alcohol, bromides, and white lead.

Among the close personal friendships made by Robert W. de Greeff during his visits here were: Dr. Leo H. Baekeland, Dr. Herbert Dow, Dr. Harold H. Fries, Evans McCarty, Caesar Grasselli, William S. Gray, Walter Rowley, William T. Mayer, Elon H. Hooker, William H. Nichols, and many others. All of these friends visited him in England and the interests of their firms were represented by Greeff & Co. abroad for many years, and in some cases, still are.

Closely related to his American interests was R. W. de Greeff's interest in quinine because the United States was such an important market. In the early nineties, he became one of the founders of the Nederlandsche Kininefabriek, Maarssen, Holland, which later grew to be the world's largest producer of quinine salts. Greeff & Co., Ltd., distributed this production throughout the world. Subsequently, the firm also became distributors of quinine salts for the Amsterdamsche Chininefabriek, and the Bandoengsche Kininefabriek.

By 1914 the American business had so grown that it was decided to open a branch office in New York in charge of Robert H. de Greeff, nephew of the founder. In 1918 this organization was incorporated as R. W. Greeff & Co., Inc., with Robert H. de Greeff as president. During World War I, the foreign business of the American company grew considerably and included exports to all the Allies. A large portion of the dyestuffs exported by National Aniline Co. were handled by it, as were intermediates supplied by Calco Chemical Co.

With the termination of World War I, R. W. Greeff & Co., Inc., faced readjustment. With the return of European competition by 1920-21, export business fell away rapidly. In the postwar period the American company continued to be an active importer of chemicals. However, the greatest change in policy involved developments in the field of domestic distribution. The representation of American chemical manufacturers for the sale of their products in the United States became the most important part of the business. With the subsequent acquisition of the interest owned by the London firm, the Company became a completely American organization principally interested in the domestic chemical industry.

Among the domestic chemical manufacurers who became principals of R. W. Greeff & Co. Inc. were: Norwich Chemical Co. (acetone); Fries Bros. (aromatic and pharmaceutical chemicals); Titanium Pigment Co. (sodium sulfide); Otto Chemical Co. (sodium acetate); Texas Carbon Industries, Inc. (carbon black); Shell Chemical Co. (acetone, diacetone, isopropyl alcohol, methyl ethyl ketone, methyl isobutyl ketone, Shell carbon, etc.); General Foods Corp. (caffeine); Montrose Chemical Co. (ergosterol); American Norit Co. (activated carbons).

In recent years Greeff has played an important role in developing markets for new products. Among these are tricresyl phosphate and DDT made by Montrose Chemical Co.; vitamin concentrates, Collett Corp. (now Collett-Week-Nibecker, Inc.); amino acids, Van Camp Laboratories; chlorophyll, carotene, xanthophyll, and phytol, Valley Vitamins, Inc. (subsidiary of Godfrey L. Cabot, Inc.); domestic agar, Beaufort Chemical Corp.; inositol and calcium phytate, A. E. Staley Manufacturing Co.

Present headquarters are at 10 Rockefeller Plaza, N. Y. City, with a branch office at 2205 Tribune Tower, Chicago. The officers are: Robert H. de Greeff, president; Ira Vandewater, connected with the firm since 1918, vice-president and comptroller; Edwin G. Jacobi, treasurer; Philip C. Burnham, secretary.

C. P. HALL COMPANY opened for business July 15, 1919, to supply the rubber manufacturers of Akron with necessary chemical raw materials. Charles P. Hall, who had dropped a budding career in purchasing to turn to selling, was the owner and only employee. A room at home served as his office.

Concentration of rubber manufacturing in Akron has been responsible for many an allied business and industry in this Ohio city. As the rubber plants grew, the demands on suppliers of raw materials, especially chemicals, increased accordingly. Back in 1919 the problems and possibilities of this situation were clear to Charles Hall, a young buyer of the Firestone Tire & Rubber Co., who had come from West Virginia where he had been an oil field superintendent. Akron's strong position in rubber products at the end of World War I gave him an idea. He knew the difficulty manufacturers frequently had obtaining adequate supplies of chemicals from far-away suppliers. On top of this was the cry for newer and better accelerators, stabilizers, and other compounding ingredients.

Oddly, the coal strike of that winter which threatened to shut down the rubber plants, did not hamper C. P. Hall. Because of his early connections, Hall had little trouble getting many an oil tankcar routed to Akron. Oil was a life-saver for the industry; it kept the boilers operating; it provided Hall's new business with its first capital.

At the outset a sales agent, Hall later became a jobber, and then a producer. His objective from the start was to develop rubber chemical specialities. When in the early 1920's the price of pine tar, a softener and plasticizer in compounding, rose, Hall introduced Para Flux as a substitute. The Company also developed a number of antioxidants, such as Stabilite (diphenylethylenediamine). In 1927 it brought out SPDX (lead dithiocarbamate). Then followed Para Lube, Para Flux 2016, Heavy Para Flux, Arolene, and reclaiming oils.

As the rubber plants fanned out over the nation, Hall Co. followed. A West Coast branch was opened in 1928 in Los Angeles and later in San Francisco. A blending plant was established in Southgate, suburb of Los Angeles, and in 1945 a plant was built in the Clearing Industrial District of Chicago to serve the increasing number of rubber factories that sprang up in the Middle West during the war.

In 1930 Hall Co. moved from the Cotter Warehouse, which served as its first plant, to a new site at 568 E. Crosier St. in Akron. That year the Company was incorporated and new emphasis placed on research directed by Charles P. Hall and vice-president Arthur E. Warner, who died in 1946. He was succeeded by Thomas L. Stevens, who was a salesman for the Company for 16 years. The research program was greatly expanded in 1940, with outside assistance. Research in rubber compounding was turned over to the Smithers Laboratories in Akron, while organic research was assigned to the Battelle Memorial Institute.

Alvin C. Peterjohn, associated with the rubber industry since 1915 when he graduated from Case School of Applied Science, joined the Company in 1947 as technical director. Hall's first associate when he began his chemical enterprise was Martha M. Dunphy, a former rubber company buyer, who was secretary until her death in 1939. Luther G. Hummel became secretary in 1941. When the California and Illinois branches were organized as separate companies, he became secretary-treasurer of all three companies.

Recently the Hall Co. completed its own rubber service and chemical laboratory which is now serving the industry.

W. C. HARDESTY COMPANY, INC., was established Oct. 1926 through the mutual interests and business relationship of William C. Hardesty and John Stead. Hardesty was for many years with the D. B. Martin Co. in Philadelphia, and with its successor, the Wilson-Martin Co., makers of fatty acids, and was enthusiastic about the potential possibilities of this industry. Stead was an official of Binney & Smith Co. which had contributed considerably to developing the rubber industry's interest in the use of stearic acid. The fatty acid industry of that day was undeveloped. Some fatty acid manufacturers were controlled by packing-house interests, which thus created intracompany consumers of the fats and tallows from packing houses; others also made soap or candles and so consumed much of their own fatty acids.

The original plant of the Hardesty Co. was established at Carnegie, Pa., Nov. 1926, solely for the production of fatty acids. Its president was W. C. Hardesty; vice-president, John Stead; treasurer and assistant secretary, J. E. Roan; secretary and assistant treasurer, J. M. Graham. On the board of directors besides Hardesty, Stead, and Roan, were A. F. Kitchel and William D. Ahearn. The first products made were stearic acid, oleic acid, crude glycerin, stearin pitch, and animal and vegetable fatty acids.

While employing the techniques and equipment used by the industry since its inception, the Company sought new methods and improvements of its products. The then-recent great strides made by the petroleum industry in distillation and hydrogenation were carefully studied. Esterification was explored and new procedures for separating solid and liquid fatty acids were investigated. Before most of these undertakings could be translated to full-scale production, a disastrous fire wrecked the plant, Apr. 1929.

In Dec. 1929, the Century Stearic Acid Candle Works of 380 South St., N. Y. City, was purchased and production resumed there. This company became known as the Century Stearic Acid Candle Works, Inc., and operated as a wholly owned subsidiary of the Hardesty Co. The Century business was established in 1800, one year prior to Thomas Jefferson's election as third President of the United States. Its early fortunes waxed and waned with those of the young Republic, which it served well as a manufacturer of tallow candles, and until its sale in 1929, the enterprise remained in the Mitchell family whose name it originally bore. Century had been producing stearic acid, oleic acid, and glycerin for a great many years; its candles were made entirely of stearic acid. But Hardesty Co. abandoned the candles business and devoted all attention to the popular items in the fatty acid group.

Expansion of operations at this location being almost impossible and railroad facilities lacking, after the first year the Century plant was given up and temporary quarters were established in Philadelphia. For a permanent location, Dover, O., was selected in 1933, when the Philadelphia operations were given up. Also in 1933 a new plant was established at Los Angeles, the first fatty acid plant on the West Coast. The original quarters being outgrown by 1937, a larger building was erected. These expanded production facilities were of incalculable importance to the splendid production records achieved by West Coast fatty acid-consuming industries during World War II. In 1938 Hardesty established a fatty acid factory at Toronto, the first in the Dominion, which was considerably enlarged in 1944 to supply the greatly accelerated wartime demands.

By this time the activities of the Company had expanded to include all the popular and many special and less-known types of fatty acids; hydrogenated fats and fatty acids, of which Hardesty was one of the first makers; and derivatives of

various fatty acids. In 1939, at Dover, the Company undertook the production of the hitherto scarcely known sebacic acid, with the aid of Amecco Chemicals, Inc., of Rochester, N. Y. Out of this effort grew Hardesty Chemical Co., Inc., a separate organization which produces sebacic acid, capryl alcohol, and their esters, and various plasticizers and synthetic organic chemicals. Petroleum sulfonates, unrelated to fatty acids chemically but much akin in several industrial applications, were added in 1940. A unit at Philadelphia for manufacturing stearic acid, oleic acid, and glycerin, was added in 1945.

The present (1946) directors of W. C. Hardesty Co., Inc., are John Stead, chairman; W. C. Hardesty, president; F. R. Cantzlaar, secretary-treasurer; A. F. Kitchel, S. V. Smith, N. L. Smith, D. F. Cranor, H. M. Abbott, W. J. O'Connell, and Edward Jobbins.

HARSHAW CHEMICAL COMPANY goes back to 1892, when William A. Harshaw, who had had several years' experience in handling chemicals for wholesale drug houses in Kansas City, Chicago, and Cleveland, founded the Cleveland Commerical Co. to deal in oils, pigments, dry colors, and other chemical commodities. Initial capitalization was $10,000 and the personnel numbered five, including Harshaw. In 1897 Harshaw founded the C. H. Price Co. with headquarters at Elyria, O., to manufacture chemicals. The two companies were combined in 1898 as the Harshaw, Fuller & Goodwin Co. The present name was adopted in 1929, the year the Company acquired its present executive offices and research laboratories at 1945 E. 97th St., Cleveland.

From the outset the Company has had a steady growth and today does a business of more than $30,000,000 a year, with capital assets at approximately $10,000,000. It manufactures hundreds of different chemical products and employs more than 1,700 people. It is growing at a faster rate than ever under a policy that stresses adequate research, well-equipped plants, and nation-wide distribution of products through its own sales organization.

The first manufacturing was done at Elyria, on the present site of the Company's plant. A second plant was purchased in 1907, in Brooklyn, O., now a part of Cleveland. In 1914 a glycerin refinery was constructed at Philadelphia, thereby not only expanding the Company's manufacturing capacity, but also providing seacoast facilities. With these three plants the Company was in a position to meet the constantly changing chemical requirements of its customers in established industries, as well as in the new industries being established during the early decades of the century. In 1940 the Company acquired manufacturing facilities on the West Coast when it purchased the Menardi Metals Co. plant in El Segundo, Calif. Operations at first restricted to antimony products are being extended to other chemicals.

The Harshaw Chemical Co. is exclusive sales agent for New York-Ohio Chemical Co., Nyotex Chemicals, Inc., and Lake Chemical Co. New York-Ohio was formed jointly with the Stauffer Chemical Co. in 1941. It operates a plant at Niagara Falls, N. Y., making aluminum chloride, boron trichloride, and antimony trichloride; another at Dominguez, Calif., for anhydrous hydrochloric acid.

In June 1942, Stauffer, Consolidated Chemical Industries, Inc., and Harshaw formed Nyotex Chemicals, Inc., to manufacture anhydrous hydrofluoric acid, anhydrous aluminum chloride, quicklime, and hydrated lime in Houston, Tex. In Nov. 1945 Harshaw Co. joined Calumet & Hecla Consolidated Copper Co. to form the Lake Chemical Co. for manufacturing copper fungicides and other copper chemicals in a plant at Calumet, Mich.

Throughout World War II, 85% of all production of the Company went into

making weapons of war; the balance, for essential civilian requirements. Several research projects were successfully completed for the Armed Forces. In recognition of its help in the production of the atomic bomb, Harshaw received one of the two four-star Army-Navy "E" awards to be given in the entire nation.

The Company manufactures chemicals primarily for industrial consumption, the principal ones being catalysts for the petroleum industry; chemicals and anodes for electroplating; pigments and cobalt, managanese, and lead driers for the paint, varnish, linoleum, and printing ink industries; metallic soaps, such as aluminum and zinc stearates; palmitates, etc.; anhydrous and aequeous hydrofluoric acid, fluorine, and various fluorides; refined glycerin; salts and oxides of cobalt, nickel, chromium, copper, tin, zinc, antimony, cadmium, manganese, etc.; opacifiers for ceramics, such as tin oxide, antimony oxide, sodium antimonate, Uverite; ceramic colors, special glazes, and porcelain enamel frit; synthetic optical crystals; fungicides.

Sales offices, in addition to the main office in Cleveland, are located in Chicago, Cincinnati, Detroit, Houston, Los Angeles, New York, Philadelphia, and Pittsburgh. Supplementing this coast-to-coast service are sales representatives in Chattanooga, San Francisco, Seattle, and Portland, Ore.

In addition to industrial chemicals, Harshaw has been supplying industrial laboratories, schools, and colleges with reagent chemicals, laboratory apparatus, and equipment since 1936, through its Scientific Division, with sales offices and stocks located in Cincinnati, Detroit, Philadelphia, Los Angeles, and Cleveland.

It maintains technical specialists who work in collaboration with a large group of research chemists. The balance that has been maintained between research, expansion, and diversification has enabled Harshaw to keep pace with rapid changes and the development of new products, materials, and processes.

The ideals and principles of the founder, who died in 1940, are still faithfully being carried out by the present management: W. J. Harshaw, president; R. H. Giebel, W. C. Hovey, W. W. Lawson, J. W. Lerner, and C. S. Parke, vice-presidents; D. T. Perry, secretary-treasurer.

HARTMAN-LEDDON COMPANY started out with a personnel of one, upon the first anniversary of Armistice Day, Nov. 11, 1919. Growth to its present status was slow, but despite many impediments, by 1929 it had acquired some form and strength. During the depression no employee was discharged even though there was a 50% decrease in business, rather all available time was applied to research and development. The wisdom of that policy became evident in later years.

The founder of the Company, Milton I. Hartman, had been employed during the early years of World War I by a company which extracted natural dyes. One of the products was logwood extract, whose principle, hematoxylin, is an essential stain for microscopy of body tissue. Direct association with the problem of hematoxylin supplied to the Army Medical Department stimulated Hartman's interest in biological stains of comprehensive variety. Public health authorities were badly handicapped because all prewar supplies had come from Germany. American dyes sold during the war were generally unsuited to laboratory work.

The small enterprise established originally had sought to produce all the stains needed in microscopy, but it was soon realized that research would be required far beyond the Company's financial capacity. In 1921, however, Francis P. Garvan, then president of the Chemical Foundation, secured a large grant and a committee was appointed by the Society of American Bacteriologists to inaugurate a collaborative study by various scientific societies interested in biological stains and such companies as Hartman-Leddon interested in their commercialization. The com-

mittee eventually became a self-supporting corporation dealing with producers upon an equal basis. Twenty years later the Biological Stain Commission, as it is now called, admitted many things had yet to be accomplished. But the results available today would have not been attained without the widespread collaboration of institutional and government scientists on this subject.

Upon the outbreak of World War II, there was no disruption in ample supplies of stains for both the Army and Navy Medical Departments, and essential public health services at home and abroad. The Company produced many specialities for which it received a Certificate of Achievement from the Navy. One phase of Company research prior to the war, dealing with development of a Giemsa-type blood stain for detection of malaria organisms, was of great value to the Navy in the Pacific. Hartman-Leddon also supplied the Army with stains suited to general blood tests throughout the war. Certain of its products were employed as standards by the Army Epidemiological Service, to test hepatic function in liver disease. These are having increased application in hospital clinics. During the war the Company also developed a new, revolutionary method for producing pure hematoxylin quickly from logwood. A considerable quantity of the product went to the Army and Navy.

After the war, experimental work temporarily laid aside was resumed, leading in 1947 to the introduction of improved, completely water-soluble pH indicators. Since the close of 1945, the Company has expanded its product distribution and is currently supplying public health services in many countries. Oct. 1947, the personnel numbers 50 persons. The Company now makes many other items besides stains, but all are related to public health or medical research.

HERCULES POWDER COMPANY, producer of industrial chemicals and explosives, was organized in Oct. 1912, in conformity with a federal court decree against the du Pont Co. in an anti-trust case. The new company began business in Jan. 1913 as an explosives manufacturer, with about 1,000 employees, 15 plants and offices, including dynamite plants at Kenvil, N. J., and Hercules, Calif., and blasting and sporting powder plants in various sections of the country. The first sales offices were in Salt Lake City; Hazelton, Pa.; Pittsburgh; San Francisco; and Wilmington, Del.

The Company was still in the first stages of organization when World War I started. During 1915 it received such large orders for military powders that the capacity of the Kenvil smokeless powder plant was increased from 50,000 lb. a month to 150,000 lb. a day. To supplement its explosives output, Hercules purchased the Union Powder Co. which produced nitrocellulose and smokeless powder at Parlin, N. J. It operated the government explosives plant "C" at Nitro. W. Va., which had a capacity of 900,000 lb. of smokeless powder a day and manufactured other ingredients. The first black powder line at Bacchus opened in Apr. 1915.

All cordite manufactured in the United States for the British Government during the First World War was made at Kenvil by a process developed by Hercules men. One of the difficulties in securing the cordite contract lay in the scarcity of acetone. Hercules cooperated with the U. S. Industrial Alcohol Co. in designing a plant at Curtis Bay, Md., for the production of acetone from fermentation acetic acid. It also erected a kelp plant at San Diego, Calif., where millions of pounds of acetone and other solvents were produced, as well as enough potash to make all the black powder needed for the Army. The greatest monthly production of acetone in the United States before the war was 500,000 lb. Before the war ended, Hercules had increased this to 1,900,000 lb. a month. The kelp plant was dismantled in

1920, having served its purpose, but the knowledge in organic chemistry gained proved of great value in the Company's later expansion.

By the end of the war, Hercules had turned out over 46,000,000 lb. of cordite, 3,000,000 lb. of small-arms powder, over 54,000,000 lb. of nitrocellulose cannon powder, altogether over 100,000,00 lb. of smokeless powder. It was the country's largest producer of TNT; its plant at Hercules, Calif., being the biggest in the United States.

During those first important years, the Company's officers were: Russell H. Dunham, president; Thomas W. Bacchus, vice-president and general manager; James T. Skelly, vice-president in charge of sales; Clifford D. Prickett, vice-president and assistant general manager; Fred W. Stark, manager of the Hazelton office; and George H. Markell, secretary-treasurer. These men were the first board of directors. Norman P. Rood was named a vice-president and director in 1918.

Immediately following the war, Hercules began branching out into other chemicals. In 1919 it formed an Industrial Research Department to investigate manufactures in which surplus funds could be invested and war workers given employment. The wood naval stores industry was chosen and in 1920 a plant was built at Hattiesburg, Miss., for the steam distillation of rosin from pine stumps. The purchase of the Yaryan Rosin & Turpentine Co. plants in Georgia and Louisiana the same year made Hercules the world's largest producer of steam-distilled rosin, turpentine, and pine oil.

The industry presented a challenge to Hercules engineers and chemists to improve plant practices, lower costs, and improve the quality of products. The wood rosin and turpentine then being produced did not meet the quality standards set by the gum products. Wood rosin was dark red in color, low in melting point, and had a strong tendency to crystallize in the shipping barrel. Paper manufacturers and other users preferred rosins of light color, high melting point, and no crystallizing tendencies. Pine oil was a new industrial product with only one important market as a flotation agent, and the demand fluctuated widely with mining conditions.

Gradually Hercules developed new refining methods which yielded pale wood rosins, the equal of gum rosins in color. Its modified rosins now range from dark red to colorless. By hydrogenation rosin was rid of its tendency to oxidize, discolor, and become brittle. The tendency toward crystallization was also overcome. Plant and wood-gathering operations were greatly improved and expanded. New extraction processes increased the yields and gave additional products. Although wood rosin, turpentine, and pine oil are produced at fixed and unchanging ratios to each other, Hercules was able to convert the slow-moving products into faster-moving products and improve the less valuable ones. It developed a higher grade of turpentine and pine oil and from them fractions which became the bases for a whole series of new chemicals.

At the close of World War I, nitrocellulose had practically no peacetime value. Within a short time, however, it was adopted by producers of photographic film, plastics, and lacquers. The biggest user of nitrocellulose lacquer was the automobile industry and as that industry grew, the consumption of nitrocellulose in lacquers increased from about 2,000,000 lb. in 1919 to over 35,000,000 lb. in 1946. By 1939, 89% of the nitrocellulose went into nonexplosives, while of the remaining 11% used in explosives a substantial part went into industrial dynamite.

Purchase of the Virginia Cellulose Co. of Hopewell, Va., in 1926, enabled Hercules to produce its own chemical cotton pulp from which nitrocellulose and other cellulose products are made. In 1926 the chief outlets for chemical cotton were papermaking and such nitrocellulose products as lacquers, Celluloid, photo-

graphic film, and explosives. A new outlet, the rayon industry, appeared within a few years, however, and soon became one of the leading consumers. At first, only cuprammonium and acetate rayons used chemical cotton. Later, viscose rayon, previously made entirely from wood pulp, began using about 40% chemical cotton with wood pulp. Today chemical cotton's largest use is in the manufacture of high-tenacity viscose rayon for tire cord.

The commercial success of nitrocellulose encouraged the development of other cellulose chemicals to supplement it in formulations to which it would not apply: cellulose acetate, ethylcellulose, and recently sodium carboxymethylcellulose, which supply many desirable characteristics to lacquers, paints, and other protective finishes. As new applications for cellulose chemicals became apparent, production of nitrate and acetate at the Parlin plant was expanded. A unit for ethylcellulose was put into operation adjoining the Virginia Cellulose plant at Hopewell in 1939; another for sodium carboxymethylcellulose was added in 1946.

Parlon, Hercules' chlorinated rubber, another product of the Parlin plant, is an ingredient in moistureproof and moldproof paints for concrete and metal floors and walls, where its high resistance to the action of chemicals increases the life of the finish.

In 1928 Hercules organized its operations into four distinct departments. The general managers were: Explosives Department, Charles A. Bigelow; Naval Stores Department, Leavitt N. Bent; Cellulose Products Department, Anson B. Nixon; and Virginia Cellulose Department, Philip B. Stull. Five new directors were elected—Bent, Bigelow, Charles A. Higgins, Charles C. Hoopes, George M. Norman—bringing the total to 12, and from its membership an executive committee and a finance committee were created. On the first executive committee were Dunham, chairman; Bacchus, Skelly, Prickett, Stark, G. Gould Rheuby, and Rood; on the finance committee, Skelly, chairman, Rheuby, Higgins, and Hoopes. In 1930 Rheuby and Higgins were elected vice-presidents. They served in that capacity with Bacchus, Skelly, Prickett, and Rood.

The Company's association with the paper industry through the sale of rosin led, in 1931, to the purchase of Paper Makers Chemical Corp., which later became the Paper Makers Chemical Department. W. J. Lawrence, president of the corporation, became a director of Hercules in 1932 and vice-president in 1936. Plants at Kalamazoo, Mich., Holyoke, Mass., Savannah, Ga., and other parts of the country now produce rosin size, casein, and other chemicals, not only for the paper industry, the principal consumer, but for other manufacturers as well. Dresinate 731, a Paper Makers Chemical Department product, was created in 1943, in cooperation with the Naval Stores Department, for the production of GR-S-10 synthetic rubber.

The Synthetics Department, newest unit, was expanded to a full operating department in 1943, with Dr. Wyly M. Billing as general manager. Four plants, located at Mansfield, Mass., Burlington, N. J., Brunswick, Ga., and Hattiesburg, Miss., produce the synthetic chemicals which are used in paint, varnish, lacquer, adhesives, paper, printing inks, textiles, and many other products.

Hercules has maintained its position as a manufacturer and a distributor of industrial explosives. In 1914 it purchased Independent Powder Co. with a plant at Carthage, Mo., and office at Joplin. In 1915 a modern explosives plant was completed at Bacchus, Utah. In 1921 the Company purchased the facilities of Aetna Explosives Co., thereby achieving complete national distribution of explosives. By the end of that year it had an important share of the trade of the coal, copper, zinc, lead, and iron-mining industries, as well as a large part of the quarrying trade. Hercules now is the second largest producer of dynamites and blasting caps for

general industrial and agricultural purposes. Sporting powders and a limited production of military powders are included in the Explosives Department list.

The growth of Hercules business, partially created by research, brought with it a need for greater research facilities. The first laboratory experiment unit had been erected at the Kenvil smokeless powder plant in 1916. Since Hercules headquarters were in Wilmington, however, the Company decided to build a large central research laboratory there. Construction started in 1929, and the cornerstone for the Hercules Experiment Station was laid in July 1930. Since then the original unit has been expanded until it now occupies 30 buildings on 38 acres of land just outside of Wilmington.

Research on the development and uses of Hercules products and basic research are carried on at the central Experiment Station and at plant laboratories. Research and technical service representatives assist manufacturers using Hercules products; in some fields, Hercules conducts training courses for its technical personnel. Research groups at the Experiment Station, corresponding to the six operating departments, work on explosives, chemical cotton, cellulose products, naval stores, synthetics, and papermaking chemicals. Each is in close contact with development work and production at the department's plants. These operating groups are supported by several functional groups specializing in physics, pilot plant, testing and evaluation, complex physical and chemical techniques, fundamental chemistry of rosin and cellulose, and scouting research. The combination of these various sections has created one of the outstanding industrial chemical laboratories in the country.

During World War II Hercules again supplied large quantities of ordnance materials to the Armed Forces. A total of 1,836,251,870 lb. of explosives, more than 11 times the amount produced during World War I, was made, including rocket powder, TNT, small-arms powder, artillery powder, and mortar powder. The Company's principal war contribution, besides the production and development of chemicals for many industries, was the design and operation of government-owned explosives plants. The construction cost $486,000,000, the explosives, propellants, and other materials produced, $428,000,000. A foremost contribution to war production was the development of a new method for making rifle and cannon powder from wood pulp. This process not only helped to avert a critical shortage in cotton linters required by American industry for many other purposes, but it also obviated changes in powder-producing equipment. Two Hercules departments participated in the production of the VT-Fuse, which detonates a projectile automatically when it reaches the correct proximity of either a moving or stationary target. The knowledge and experience gained through wartime research have been applied to postwar production: Hercules is expanding the number of products made and finding new applications.

In Mar. 1939 the Company's first president, Russell H. Dunham, retired and was succeeded by Charles A. Higgins, who also became board chairman in June 1944. Other officers today are Leavitt N. Bent, William R. Ellis, Petrus W. Meyeringh, Mahlon G. Milliken, Edward B. Morrow, Anson B. Nixon, and Philip B. Stull, vice-presidents; Francis J. Kennerley, treasurer; George B. Baylis, secretary. All but Baylis are on the board of directors, which also includes Wyly M. Billing, A. E. Forster, J. J. B. Fulenwider, J. B. Johnson, Lloyd Kitchel, and Reginald Rockwell. Members of the executive committee are Higgins, Bent, Ellis, Meyeringh, Milliken, Morrow, Nixon, and Stull. Department general managers are: Fulenwider, Cellulose Products; Johnson, Explosives; Forster, Naval Stores; Rockwell, Paper Makers Chemical; Billing, Synthetics; and Kitchel, Virginia Cellulose. Heads of auxiliary departments are: Theodore Mar-

vin, Advertising; Ernest S. Wilson, Engineering; David M. Houston, Export; E. Way Highsmith, Legal; Lemuel C. McGee, Medical; L. W. Babcock, Personnel; Andrew Van Beek, Purchasing; Emil Ott, Research; John S. Shaw, Safety; Morris W. Sheppard, Traffic.

HEYDEN CHEMICAL CORPORATION has grown in a quarter of a century from a single chemical plant to a company whose interests stretch from coast to coast. From a maker solely of medicinal and industrial chemicals, it has become producer of basic chemicals, intermediates, medicinals, drugs, and antibiotics.

The name Heyden comes from Germany where the original Chemische Fabrik von Heyden, A.-G., was founded in Radebeul in 1874. Among its personnel were Dr. H. Kolbe, who synthesized salicylic acid, and Dr. R. Schmitt, who advanced its commercial production.

The American affiliate of the Company was established as the Heyden Chemical Works, in Garfield, N. J., in 1900, by George Simon, who had been export manager for the German concern in London before coming to the United States. The plant facilities, consisting of two buildings on the Passaic River, were purchased from Fritzsche Bros., and included equipment for the purification and distillation of essential oils. The initial product was saccharin, the first to be commercially made in this country, and this was quickly followed by salicylic acid and its derivatives.

Soon thereafter Dr. Clemens Kleber, a Fritzsche chemist who had joined the Company, perfected a process for formaldehyde, in those days used almost exclusively as embalming fluid and disinfectant. Annual consumption in this country probably didn't total over 1,000,000 lb. (500,000,000 in 1946), but equipment was built to produce 1,000,000 lb. per year. Today, formaldehyde is still one of Heyden's most important products.

The original Heyden Co. also pioneered in medicinal colloids. Colloidal silver under the name Collargol was first made at Garfield in 1901. A long list of other colloids followed, including silver proteinate and nucleinate. Other medicinal chemicals made by Heyden during these early years included medicinal creosote, creosote carbonate (Creosotal), guaiacol, guaiacol carbonate (Duotol), and potassium guaiacol sulfonate. Production of sodium benzoate coincided with its acceptance in 1905 by the Pure Food & Drugs Administration as a food preservative.

A sales office which had been established in 1902 at 44 Pine St., in N. Y. City, handled these products, as well as salicylates, bromides, hexamethylenetetramine, paraformaldehyde, and sodium benzoate. By this time Garfield was occupying the entire block along the Passaic River where the first building was erected. The Heyden Chemical Works came to an end with the entry of the United States into World War I. It was taken over by the Alien Property Custodian and in 1919 sold at auction to Allan A. Ryan, who incorporated it under the title, Heyden Chemical Company of America, Inc. In 1922 Bernard R. Armour became associated with the Company, which was organized in New York under the present name in 1925 and its sales and administrative offices there enlarged.

By 1926 the Company was more than twice its original size, partly as the result of the purchase of the Norvell Chemical Corp., Fords, N. J. This merger brought back to Heyden George Simon, one of Norvell's organizers, as vice-president and treasurer; Dr. Robert Tischbein, an old associate of Simon's at Garfield; and Dr. R. W. Harris and J. P. Remensnyder, today vice-presidents of Heyden. With the Norvell plant on the Raritan River came also production facilities for formaldehyde, glycerophosphates, mercurials, citrates, oxalates, medicinal creosote, guaiacol, silver salts, acetanilide, benzoic acid, benzaldehyde, benzyl chloride, benzotrichloride,

and benzoyl chloride. The last five were developments of Dr. Harris, a specialist in chlorination. One of the first moves was to eliminate overlapping production. For example, formaldehyde was concentrated at Garfield, but a new and improved process which had been developed at Fords was utilized. The Company thus embarked on a 15-year period of steady growth, its principal officers at the time, in addition to president Armour, Simon and Dr. Tischbein, being F. William Weckman and Dr. Walther Ost.

In the years before World War II, the Company added such chemicals as mono, *o*-, and *p*-chlorotoluene, *o*- and *p*-chlorobenzaldehyde, *o*- and *p*-chlorobenzoic acid, potassium creosote sulfonate, calcium guaiacol sulfonate, and the medical specialties Sulfoderm, Thorotrast, Umbrathor, Gastrosil, etc.

Another important development was the commercial production of pentaerythritol and its derivatives, useful in resins and paints, which were marketed under the trade names Pentek and Pentawaxes. Pentaerythritol, also a base for explosives, was made available to the Armed Forces in the war, large quantities going into rockets and bazookas. Combined with other ingredients, hexamethylenetetramine, long produced by Heyden, became RDX, the explosive in the famous "blockbuster" bombs. During the war Heyden also operated the Army's Cherokee Ordnance Works, at Danville, Pa., which turned out approximately 70% of the hexamethylenetetramine used by the Armed Forces.

At Fords, also, Heyden engineers designed equipment for the quantity separation of *o*- and *p*-chlorotoluene in exceptionally pure forms. *o*-Chlorotoluene proved to be the best intermediate for khaki dyes and *p*-chlorotoluene, converted into dichlorobenzoic acid, became a basic raw material in the antimalarial atabrine. Heyden produced a major proportion of these materials during the war. It also branched out into another field—antibiotics. In 1943 the Company agreed to operate a government-built plant at Princeton, N. J., for production of penicillin. At the last moment this plant was switched from the bottle production method to the newer vat fermentation process. Despite this complication, the plant was in production early in 1944 and before the end of the war Heyden was cited by the Government for exceeding by many times the plant's rated production capacity.

President Armour began implementing his far-seeing plans for Heyden postwar—by now the Company had become a Delaware corporation—and, with an eye to both broadening and integrating its interests, he launched a series of acquisitions. The penicillin plant in Princeton was purchased from the Government in 1946. The prior year C. E. Jamieson & Co., Detroit, and C. E. Jamieson & Co., Ltd., Windsor, Ont., manufacturers and distributors of proprietary, clinical, and ethical drugs, were acquired and the Jamieson Pharmacal Co. set up to handle these products. Also in 1945 Heyden increased from one-third to two-thirds its interest in American Plastics Corp., Bainbridge, N. Y. The first interest in these manufacturers of casein plastics was obtained in 1931. The balance of the shares was acquired in 1948, so that American Plastics is now a wholly owned subsidiary.

In 1946 Heyden bought approximately 20% of the common stock of the American Potash & Chemical Corp. in Trona, Calif., producers of soda ash, borax, and similar products. Armour became chairman of the executive committee and the board, and three other Heyden officials became directors. Then the Memphis, Tenn., phenol plant built during the war but never operated, was bought from the War Assets Administration and began producing chlorine, liquid caustic, hydrogen, and later chlorobenzene products. In antibiotics Heyden began research into streptomycin in a plant in Brooklyn. It was also in 1946 that Heyden, as its contribution to the government program to provide fertilizer for needy countries abroad, agreed to operate for the War Department the $60,000,000 Ordnance Works at

Morgantown, W. Va., where nearly two-thirds of the anhydrous ammonia required for the program was to be produced.

Early in 1947 Heyden added the Nyal Co. of Detroit, drug distributors, by acquisition of virtually all the common stock from Sterling Drug Inc. Nyal distributes a line of drugs and sundries through a network of franchised retail outlets.

Today Heyden is a thoroughly modern, integrated company, making not only the "Fine Chemicals" of its trade-mark, but heavy chemicals, fine drugs, fine antibiotics, and fine progress which continue to be guided by president Armour and other key officers: Dr. Harris, Remensnyder, Dr. Donald B. Keyes, Dr. R. N. Lulek, Simon Askin, all vice-presidents; Paul van der Stricht, secretary; and George B. Schwab, treasurer.

HOFFMANN-LA ROCHE, INC., had its beginning over 50 years ago in Basel, Switzerland. Its founder, Fritz Hoffmann-La Roche, was a forward-thinking Swiss businessman who foresaw good possibilities in the young fine-chemical industry. The starting personnel consisted of a handful of people and included a young Swiss chemist, Emil Barell, who was chief of staff and functioned in a myriad of capacities during the early years of the business. Today (1947) Dr. Barell, in his early 70's, is still the active head of the Roche companies throughout the world. Indeed, the names Hoffmann-La Roche and Barell are synonymous to those who know the history of the Company.

The young company started operations at an auspicious time. The coal-tar and synthetic organic chemical industries were in their infancy. Within a little more than a decade, F. Hoffmann-La Roche & Co., Ltd., was doing business in all important countries of the world. It operated in three main fields: development of ethical prescription specialties; manufacture of coal-tar and synthetic organic chemicals, including vanillin, coumarin, phenolphthalein, salicylic acid products, guaiacols, etc.; extraction of such important plant alkaloids as atropine, colchicine, hydrastine, scopolamine, and many others.

The Swiss company, realizing that it could only operate successfully in the big United States market through an organization of its own, formed a New York corporation, the Hoffmann-La Roche Chemical Works, Inc. Operations started in 1905 in one of the old-fashioned buildings on Maiden Lane, then in the drug center of N. Y. City. The American company operated principally as a sales agency for the Swiss parent, as in those days there was little fine chemical manufacturing in the United States and low tariffs favored free trade. It prospered modestly during the next 10 years and by the outbreak of World War I was fairly well known as the principal importer for such basic commodities as cresol, cresylic acid, phenol, vanillin, coumarin, phenolphthalein, and alkaloids.

World War I completely cut off the American company from its source of supply and for the next seven years it concentrated on developing its ethical prescription specialties and in selling American-made fine chemicals. However, import and trading operations had become unattractive and in the early 1920's the Company altered its policies with the object of building up the specialty business until plans could be made for large-scale manufacturing operations in the United States. While the American company was marking time, the international company had been undergoing intensive development.

In 1928 the American company broke ground for a plant in Nutley, N. J., and in June 1929 operations were moved there and the company name shortened to Hoffmann-La Roche, Inc. Item after item was added as building after building became available, and by World War II the Company was 98% independent of Europe for

supplies. The Nutley plant was now a principal source of barbiturate drugs. One of the most modern and highly mechanized units for producing strychnine was processing many carloads of nux vomica yearly from India and French Indo-China. In the early 1930's the Company pioneered in developing processes for manufacture of vitamins B_1, B_2, C, E, and B_6. Hoffmann-La Roche, Inc., today is one of the principal manufacturers of ethical specialties and specialized fine chemicals.

The plant is located in a pleasant suburban community, set in parklike surroundings on more than 100 acres. It has a dozen major buildings and several dozen lesser structures, a model for the industry, and employs about 2,000 people. New construction is under way which in the next several years will cost some $5,000,000, for new chemical developments to which the Company looks forward in all confidence. These plans are buttressed by an extensive research program centered in Welwyn, England; Basel, Switzerland; and Nutley, N. J.

HOOKER ELECTROCHEMICAL COMPANY is one of the oldest and largest of the 36 companies producing electrolytic caustic soda, chlorine, and hydrogen in the United States. Supplementing these three basic products, it has diversified into more than 100 derivatives, most of which are being produced today (1947). In addition to its original plant at Niagara Falls, N. Y., started in 1906, the Company put into operation in 1929 a plant at Tacoma, Wash. Both plants have been expanded many times.

The early days of the Company revolve largely around Elon Huntington Hooker, founder and president till 1938. In 1901 he resigned as N. Y. Deputy Superintendent of Public Works to join the Development Co. of America, many of whose stockholders were his friends. In 1903 he reorganized this company as the Development & Funding Co., whose goal was industrial promotion. William A. Perrin, a lifelong friend, was the first treasurer and intermittent associate for 43 years. Offices were at 40 Wall St., N. Y. City.

Elon Hooker's approach to prospective investors in his new company is quoted as: "I have no definite idea concerning the materials my company will produce, nor the processes to be employed. My plan is based upon the sincere belief that given a reasonably sound type of business, the success of a venture depends upon the quality of management. I have every confidence that I can gather around me and hold together such men as may be necessary to handle properly the engineering, chemical, and financial sides of the business."

In 1903 the Development & Funding Co. became interested in the electrolytic decomposition of sodium chloride solution into caustic soda, chlorine, and hydrogen. The idea was original with Clinton P. Townsend, brilliant young examiner in the U. S. Patent Office, who communicated it to Elmer A. Sperry, one of the pioneers of the electrical industry and later inventor of the gyroscope. From 1901-3 the two men combined their energies and thoughts in developing a process and cell. Development & Funding obtained space adjoining the Edison Electric Station in Brooklyn, N. Y., and built two 1,000-ampere Townsend cells which were operated until Oct. 1904, in charge of Willard Hooker, Elon's youngest brother, assisted by Cooper N. Lansing, George W. Stone, and George Eyer. Elon engaged as consultants his older brother, Albert H. Hooker, then chief chemist of Heath & Milligan Paint Co., Chicago, and Dr. Leo H. Baekeland, inventor of Velox and Bakelite.

Upon completion of the experimental work in Brooklyn and of negotiations for patent rights, engineering work was started on the design of a commercial plant having a capacity of five tons of caustic soda and eleven of bleaching powder per day. Niagara Falls was selected as the location because of abundant power then

available from the young but rapidly growing hydroelectric power development on the Niagara River, close proximity to the practically inexhaustible salt deposits of western New York, and excellent transportation facilities connecting with near-by potential markets. Ground was broken on May 5, 1905, and the first commercial installation put into operation on Jan. 1, 1906, under Willard Hooker as superintendent, and Jasper M. Rowland, civil engineer, H. Paulus, mechanical engineer, and G. W. Stone, electrical engineer, as shift superintendents. Willard Hooker was assistant treasurer of the Development & Funding Co. in 1904 and secretary-treasurer in 1905. Besides superintending the Niagara plant during the first few years of its operation, he was treasurer of the Hooker Co. from its incorporation in 1909, director since 1915, and from 1916 until his death in 1937, vice-president in charge of development and research.

The design and construction of the Niagara plant was under the direction of civil engineer Clarence W. Marsh, who later was chief engineer until he left the Company early in 1916. His successor was Jasper M. Rowland, mechanical genius, who was responsible for the first rubber-lined tankcars for transporting muriatic acid ever to be used (about 1920); a fleet of ten was built and put in operation in 1910.

Two men destined to play a very important part in the growth of the Company joined Dec. 1907. Edward R. Bartlett's first job with the Development & Funding Co. was in purchasing, bookkeeping, timekeeping, etc. He later became assistant secretary and assistant treasurer, assistant superintendent, superintendent, vice-president and works manager (1924), vice-president and treasurer (1938), executive vice-president (1941), and finally president in 1945. Thomas L. B. Lyster began as engineer, then chief engineer in 1916, director of development in Apr. 1919, in business for himself but part-time Company consultant in 1921, again full-time with Hooker in 1932, chief engineer since 1937. He was responsible for much of the engineering planning and construction, particularly during 1915-16 and the last 10 years.

The many difficulties first encountered at the Niagara plant did not prevent expansion of the daily output to seven tons sodium hydroxide and 15.4 tons bleaching powder by the end of 1907; 20 and 44 tons, respectively, by Oct. 1909.

Albert H. Hooker came with the Company permanently in 1908 as chief chemist. He was technical director from 1911 until his death in 1936. His contributions to sodium chloride electrolysis are still utilized, one of the most important, worked out cooperatively with Dr. W. J. Marsh, being a crystallization process for reduction of salt and other impurities in standard electrolytic caustic soda. This work opened the entire caustic market to the diaphragm cell caustic producer, including the rayon industry, which has become the most exacting and largest outlet.

In accordance with the plan whereby the Development & Funding Co. would become a "development" and not an "operating" group, the Hooker Electrochemical Co. was formed Nov. 1, 1909, acquiring substantially all the property of the parent company. The first officers and directors were: Elon H. Hooker, president-director; Franklin Remington and Michael Gavin, directors; Percy K. Hilton, secretary-director; A. H. Hooker, works manager-superintendent-director; H. W. Hooker, treasurer; E. R. Bartlett, assistant secretary-assistant treasurer; George Velie, auditor.

A disastrous fire, May 1910, wiped out a good part of the Niagara plant which was rebuilt and put back into operation, Oct. 1910, with an enlarged capacity of 23 tons sodium hydroxide and 50 tons bleaching powder. A setback occurred in 1913 when a new circuit of triple-deck cells proved unsuccessful. By Sept. 1914

these had been replaced by Marsh Type E cells and two circuits of Townsend Type F cells added, resulting in excellent operation at expanded output.

John F. Bush, a friend of E. H. Hooker's who had originally suggested consideration of the Townsend-Sperry electrolytic cell in 1903, joined the organization July 1, 1910, as vice-president. He left in Sept. 1915 and shortly thereafter organized the Great Western Electro-Chemical Co. which began operating in 1916. Others who joined the Company in 1910 were E. K. Newton, now assistant chief engineer; Ralph C. Snowdon, now head chemist; and Sidney G. Osborne, now a development and research supervisor.

Harry Mix Hooker, fourth Hooker brother to join, started working for the Company in 1913 on construction. He became New York sales manager in 1918; vice-president, sales manager, and director in 1922; following the death of Elon Hooker in May 1938, president; and since June 1945, chairman of the board. Burr H. Ritter, now works chemist, and John A. Flynn also started with the Company in 1913. Flynn was appointed superintendent of the Tacoma plant in 1928 and works manager in 1941, until his death in May 1946. Benjamin K. Hotchkiss, one of the best-loved salesmen in the alkali industry, joined in 1915 and continued until his death in 1936. Levi A. Ward, brother-in-law of Willard Hooker, was secretary of the Company, 1915-41, director from 1938 until his death in 1944.

During World War I the Niagara plant was expanded in the biggest construction program yet experienced by the Company. The first real diversification came with the erection of a monochlorobenzene plant for the French Government's picric acid program. Muriatic acid was added as a by-product. A second monochlorobenzene plant, completed in 1916, was for some years the largest in the world. Following our entry into the war, a process was developed and put into operation for the production of liquid chlorine, and large plants were built to produce sulfur monochloride and picric acid for our Government.

Chemical research towards the development of new products was initiated in 1915 and carried out at Townsend's laboratory at Niagara Falls, and at the Institute of Industrial Research, Washington, D. C. J. H. Babcock started working for the Company early in 1916 at the Institute. During 1917-18 he was in charge of the government picric acid plant erected by the Company, later made assistant manager of research, and since Aug. 1933, manager of development and research in the Research Department. R. L. Murray, Bjarne Klaussen, and Frank W. Dennis joined the Company in 1916. Murray had charge of the nitric acid plant for picric acid and successively rose from Niagara plant superintendent in 1920 to chief engineer upon J. M. Rowland's death in Apr. 1932, director in 1937, and vice-president in charge of development and research since 1941. Klaussen advanced from foreman of the Benzoate Department in 1919 to works manager, Niagara plant, in 1941 and director in 1942. Dennis is now personnel director and employment manager. Paul Hooker, the fifth Hooker brother, joined in 1917 as engineer, continuing with the Company until his death in Jan. 1940. Kenneth E. Stuart, brilliant engineer, inventor and resident patent attorney since 1936, was brought in by Elon Hooker in Dec. 1917. His contributions toward the brine feed systems made possible the Hooker Type S cell.

Following Armistice Day, there was a difficult readjustment and then an inflationary period which ended in a severe depression lasting until Sept. 1921; research work had to be drastically curtailed. The Company's offices moved to 25 Pine St. in Oct. 1919. Benzoic acid, benzoate of soda, and synthetic hydrochloric acid made by burning hydrogen and chlorine were added to the Company's line in 1919, followed by *p*-dichlorobenzene, antimony chloride, and benzoyl chloride in 1920. Oil removal from the cell cathode plates was started in Nov. 1920, which

improved cell operation greatly and next year an orifice system for feeding the cells was developed which further improved and simplified operations.

Albert H. Hooker, Jr., eldest son of A. H. Hooker, Sr., started working for the Company's Sales Department in 1921. He went to Tacoma in 1928 as West Coast sales manager. His brother, Roger Wolcott Hooker, joined the Company as a salesman in 1922, becoming sales manager in 1936, director in 1937, and since 1941 vice-president and sales manager.

The first tankcar of liquid chlorine was shipped from the Niagara plant on May 18, 1922, and during the next few years the trend away from bleaching powder accelerated, necessitating substantial increases and improvements in the chlorine liquefaction plant and a heavy investment in tankcars. Great improvements were made in handling chlorine gas and the Company was one of the first to employ forced circulation triple-effect nickel evaporators for the concentration of electrolytic caustic soda.

During 1920 hydrogen gas was delivered to Hydrofats, Inc., which had a plant for hardening vegetable oils and fats adjacent to the Niagara plant. This plant shut down in Nov. 1922 but was later taken over by the Niagara Ammonia Co. to which hydrogen delivery started in May 1924. This company also ceased operations, July 1927. The buildings were bought by Hooker and turned over to the manufacture of fine chemicals. Delivery of hydrogen by pipe line to the Roessler & Hasslacher Chemical Co. (now the Electrochemicals Division, du Pont) for production of synthetic ammonia commenced Feb. 1, 1928, and has continued ever since.

The first tankcar shipment of sulfur dichloride to the Celanese Corp. was made on Apr. 4, 1925. This product was the largest outlet for chlorine, except liquid chlorine, for nearly 12 years, when it began to fall off and stopped entirely in 1939 because of a change in the Celanese process. Fortunately Hooker's chlorine diversification was well on the way by this time.

The heptahydrate crystallization process for purifying electrolytic caustic soda was put into operation in 1926 and subsequently expanded many times. During the thirties the percentage of high-grade and rayon-grade caustic soda made at Niagara by this process increased substantially. During the twenties there was a gradual trend from solid to liquid caustic, and by 1930 upwards of 75% of the Company's caustic was shipped as 50% liquid in tankcars and by 1936, over 85%.

After long experimentation, a successful method was worked out for depositing an asbestos cell diaphragm, making possible a radically new type of diaphragm cell, the Hooker Type S cell. The first cell was started upon Nov. 20, 1929, which is a milestone in the Company's history. Anhydrous ferric chloride, *o*-dichlorobenzene, and benzyl chloride were added in 1928-29.

West Coast surveys were made by A. H. Hooker E. R. Bartlett, J. M. Rowland, and Willard Hooker during 1927, looking forward to the establishment of an electrolytic plant to supply chlorine to the fast-growing bleached pulp mills in the Northwest and caustic soda to the oil refineries in Southern California. A decision was reached to erect a plant with an initial capacity of 29 tons a day of sodium hydroxide (two circuits of Type E cells) at Tacoma which had an excellent supply of cheap hydroelectric power and was centrally located with respect to pulp mills. It was planned to bring salt in by ocean-going vessels direct to the Company's dock on the Hylebos waterway connecting with Puget Sound and to ship liquid caustic by boat to the oil companies in California. Under Rowland's direction construction started in Aug. 1928, and operation, Feb. 1929, with W. A. Perrin, assistant treasurer; A. H. Hooker, Jr., sales manager; and J. A. Flynn, superintendent. A second circuit of Type E cells started up at Tacoma in 1930, and two

of Type S cells in 1936 and 1940. Storage facilities for liquid caustic were secured at Oakland, Calif., in 1936, in addition to those at Wilmington, Calif., obtained early in 1929. A plant for the hydrogenation of fish oil was installed in 1938. Ever since the start of the Tacoma plant, maritime strikes have frequently necessitated bringing in salt by rail.

No change was made in chlorine and caustic capacity at Niagara between 1916-31. By the end of 1931 the single circuit of Marsh Type E cells at Niagara and the two at Tacoma had been converted to the deposited form of diaphragm. By this time the Type S cell, which began operating Nov. 1929, looked so promising that by Aug. 1933 one entire circuit of Townsend cells had been switched over to Type S cells, thus giving substantially increased output. The switchover to the Type S cells continued from 1935-37, except for one circuit of Marsh Type E cells, which almost doubled the capacity of the plant without additional building.

The depression of 1929 cut heavily into the Company's sales at Niagara during 1930-31, but business began to pick up appreciably by the end of 1932. The Company sold the office building at 25 Pine St. and moved to new offices in the Lincoln Bldg. at 60 E. 42nd St., on May 1, 1930.

During the thirties research was expanded with more emphasis on new products and diversification of chlorine. Sulfuryl chloride and monochlorotoluene were added in 1930, thionyl chloride, trichlorobenzene, and aluminum chloride in 1931, chloronaphthalene and *m*- and *p*-nitrobenzoyl chloride in 1932. A big chlorine consumer, chlorinated paraffin, was added in 1933, with *p*-dicholoraniline, methyl benzoate, ammonium benzoate, and arsenic trichloride following in 1934. A real start was made this same year on the utilization of hydrogen in the manufacture of hydrogenated fine chemicals. Chloroanisidine was added in 1935; isopropyl chloride, cyclohexanol, methylcyclohexanol, and methyldichlorostearate in 1936; methyl stearate, dichlorostearic acid, and benzotrichloride, in 1937; sodium sulfhydrate, sodium sulfide, acetyl chloride, phosgene, lauryl pyridinium chloride, and Plasticizer E40, in 1938-39.

Further improvements were made in the handling and distribution of chlorine gas, in the quality of liquid caustic, and in the evaporation of cell liquor. Sale and delivery of steam to the Niagara Alkali Co. started in 1929 and continued until 1937. During 1938 hydrogen and steam were piped to the National Cylinder Gas Co.—an arrangement still in effect—which compresses and packages hydrogen and liquid air-oxygen into cylinders. By a license agreement with Champion Paper & Fibre Co. in May 1936, Hooker Type S cells were installed in its plant near Houston, Tex. This was the first of 30 such installations during the next 10 years, and by 1944 about 40% of domestic chlorine was produced in Hooker cells.

Upon the death of Albert H. Hooker in 1936 and Willard Hooker in 1937, R. L. Murray succeeded as director of development and E. R. Bartlett as vice-president and treasurer. On May 10, 1938, Elon H. Hooker, president of the Company since its inception, died. Harry M. Hooker was elected the new president. As part of an enlarged program of development and research, a new office and laboratory building was completed in Mar. 1938 at Niagara and the executive offices moved there in September from New York. Towards the end of the thirties and early in the forties many additional buildings and facilities were installed for expansion of diversified products.

During Warld War II the Company supplied the Government with more than 3,000 Hooker Type S cells, plus engineering and operating services, for use in nine government mines. It built six government plants at Niagara and one at Tacoma, three with its own funds, and operated them for the production of hazardous and badly needed war chemicals by Company processes. It also provided de-

signs and operating know-how for installations in three government plants away from Niagara. In connection with the atomic bomb project, Company participation included an extensive research program, the building and operation of a large plant at Niagara, the provision of design and operating information, and assistance in connection with two large installations away from Niagara. Most of these plants were shut down before the close of the war. As a result of these activities, Hooker was awarded the Army-Navy "E" six times at Niagara and twice at Tacoma; *Chemical & Metallurgical Engineering* awards for participation in the synthetic rubber program and the atomic bomb project; a special award from the Manhattan Engineering District; and the Treasury war bond award.

On Jan. 1, 1941, John F. Bartlett became treasurer of the Company; R. E. Wilkin, Eastern sales manager; and Ansley Wilcox, 2d, a lawyer, secretary. On June 20, 1945, H. M. Hooker became chairman, a position hitherto not filled, and E. R. Bartlett became the third president of the Company.

Among the Company's war products were many new hydrogenated compounds and some important new lubricant additives. Manufacture of caprylyl chloride and methylpentachlorostearate was under way in 1941, pipe-line delivery of anhydrous hydrogen chloride gas to the B. F. Goodrich polyvinyl chloride plant was started that same year, followed by tetrahydrofurfuryl oleate in 1942, dichlorobenzoic acid and sodium tetrasulfide in 1943, and tin tetraphenyl-chloropropane wax, hexachloropropylene, and hexachlorobutadiene in 1944.

A further basic output increase was accomplished at Niagara when the last remaining Type E cells were supplanted by Type S cells in Aug. 1941; chlorine utilization in diversified products reached new highs, 1942-46. At Tacoma an aluminum chloride plant erected at government expense operated from Apr. 1943 until Jan. 1946. It supplied the major aluminum chloride requirements on the Pacific Coast in aviation gasoline and styrene for synthetic rubber. Tacoma works manager John A. Flynn died in May 1946 and was succeeded by John D. Rue.

Hooker entered the postwar period of adjustment and conversion with somewhat decreased sales. About June 1946, however, the demand for products increased substantially and by the end of the year could not be satisfied, in spite of expanded output. During 1946 production of DDT and hexachlorocyclohexane began and a large plant for monochloroacetic acid was nearing completion. Expansions occurred in benzene and toluene chlorination; in chlorine, caustic, and steam-generating capacities.

In Jan. 1946 Hooker-Detrex, Inc., was organized by Hooker and Detrex Corp. of Detroit for the manufacture and sale of chlorinated solvents. Production of trichloroethylene began a year later at Tacoma, where chlorine and other materials come from Hooker's plant.

An employee representation plan in effect at the Niagara plant since 1919 was supplanted by an independent union in Jan. 1944. At Tacoma, an agreement has been annually renewed since 1937 by Company and various A. F. of L. unions. A retirement program was put into effect in Oct. 1946.

The officers and directors of the Company at the start of 1947 were: H. M. Hooker, chairman; E. R. Bartlett, E. L. Burnham, R. W. Hooker, B. Klaussen, C. S. Lutkins, J. P. Marquand, and R. L. Murray, directors; E. R. Bartlett, president; R. L. Murray, vice-president in charge of development and research; R. W. Hooker, vice-president and sales manager; A. Wilcox, 2d, secretary; and J. F. Bartlett, treasurer.

HOUDRY PROCESS CORPORATION is an integrated engineering, research, and development organization devoted to petroleum research and to the commercialization of processes and equipment evolved from this research. It was organized to bring to commercial operation a new petroleum-refining technique—the catalytic transformation of petroleum hydrocarbons, frequently referred to as catalytic cracking. Pioneer in this field is Eugene J. Houdry, who in the early 1920's initiated research at his laboratories in Beauchamp, France. During the summer of 1930 the processes he and his associates had developed were brought to the attention of H. F. Sheets, representative in France of the Vacuum Oil Co. As a result of these discussions Houdry brought to the United States laboratory equipment, personnel, and plans for a small, commercial catalytic cracking unit, more fully to demonstrate the new processes. His apparatus was assembled in the Research Department of the Vacuum Oil Co. at Paulsboro, N. J.

In 1931 Houdry Process Corp. was incorporated with this original board of directors: H. F. Abrams, H. A. Curtis, A. T. Foster, C. E. Kieser, H. S. McKinney, N. J. Muller, Houdry, and Sheets. In 1933 Sun Oil Co., Philadelphia, became actively interested in the Houdry experiments and with Socony-Vacuum (Vacuum Oil merged with Socony in 1932) became partners in the venture, each retaining an approximate third interest in Houdry Process, the remaining third being shared by Houdry and his French associates.

The world's first commercial catalytic cracking unit, a Houdry fixed-bed plant, went into production in 1936 at the Paulsboro refinery of Socony-Vacuum. Sun Oil constructed the first large-scale commercial Houdry catalytic cracking unit in 1937. American refiners were first to benefit by Houdry research. The new process made it possible to produce more usable by-products from a barrel of crude oil, a genuine contribution to the economic life of the United States, for it provided better products, more jobs, and made possible conservation of petroleum resources.

Houdry catalytic cracking contributed tremendously in World War II to the immense production of 100-octane aviation gasoline and was a large factor in the synthetic rubber program. On Dec. 7, 1941, it was ready for production of better-than-enemy aviation gasoline. Houdry catalytic gasoline had met U. S. Army specifications for aviation fuel as early as 1938. In 1940 aviation gasoline was made by Houdry-licensed plants for the British and French Governments. When war came to the United States, five major oil producers were operating 14 Houdry units and building two more—the only catalytic cracking units then in commercial use. These units were converted to aviation base stock and in the first two years that America was in the war 90% of all catalytically cracked aviation gasoline was made by the Houdry process; the greater part of such gasoline made during the war resulted from Houdry-licensed processes.

Early in 1942 Houdry offered a new catalytic cracking process, the Thermofor Catalytic Cracking (TCC) process, developed by Socony-Vacuum Oil Co. as the result of extensive work with its Thermofor clay-burning project. Immediately, the TCC process was made available to all American refiners subject to approval by the Government. Combined installation of Houdry fixed-bed and TCC processes today (1947) represents a major portion of the world's catalytic cracking capacity. The total daily catalytic cracking capacity of the world is now above 1,000,000 bbl. per day of petroleum stock, or, put another way, roughly 500,000 bbl. daily of high-grade motor gasoline or a somewhat lower production of aviation gasoline base stock could be obtained. At the same time catalytic cracking plants produce

butylenes as a by-product which went to make about one-third of the butadiene used in the synthetic rubber program during World War II.

Another Houdry-licensed process is the Houdry dehydrogenation method for the production of butadiene directly from butane. Developed under the exigencies of war, this process was used during the war and continues to be used for the production of both butylenes and butadiene.

Most Houdry-licensed processes are installed within the United States. Beyond our national borders, Houdry installations are divided into classifications: those on which installation was started before the war and those which were purchased by the U. S. Government under lend-lease. The number of catalytic cracking and treating units employing Houdry-licensed processes in operation or under construction are: *1936,* Socony-Vacuum Oil Co., Paulsboro, N. J. (1). *1937,* Sun Oil Co., Marcus Hook, Pa. (1). *1939,* Magnolia Petroleum Co., Beaumont, Tex. (2); Socony-Vacuum, Brooklyn, N. Y. (1), Buffalo, N. Y. (1), Trenton, Mich. (1); Sun Oil, Marcus Hook, Pa. (1), Toledo, O. (1). *1940,* Socony-Vacuum, E. St. Louis, Ill. (1), Augusta, Kans. (1), Paulsboro, N. J. (1), Naples, Italy (1—destroyed in war, 1944); Sun Oil, Marcus Hook, Pa. (2). *1941,* Tide-Water Associated Oil Co., Bayonne, N. J. (1). *1942,* Socony-Vacuum, E. Chicago, Ind. (1); Standard Oil Co. of California, El Segundo, Calif. (1). *1943,* Gulf Oil Corp., Port Arthur, Tex. (4); Sinclair Refining Co., Houston, Tex. (1); Magnolia Petroleum Co., Beaumont, Tex. (4); Sun Oil, Marcus Hook, Pa. (1). *1944,* Ashland Oil & Refining Co., Ashland, Ky. (2); Continental Oil Co., Ponca City, Okla. (3); Crown Central Petroleum Corp., Pasadena, Tex. (2); General Petroleum Corp. of California, Torrance, Calif. (4); Pure Oil Co., Nederland, Tex (2); Richfield Oil Corp., Watson, Calif. (4); Sinclair, Corpus Christi, Tex. (1), Houston, Tex. (1); Socony-Vacuum, E. St. Louis, Ill. (1), Paulsboro, N. J. (1); Southport Petroleum Co., Texas City, Tex. (1); Standard Oil Co. (Ohio), Cleveland (2); Sun Oil, Marcus Hook, Pa. (2); Union Oil Co. of California, Wilmington, Calif. (4). *1945,* Tide-Water, Bayonne, N. J. (1); Standard Oil (Calif.), Richmond, Calif. (2); U. S. Treasury Procurement (lend-lease), U.S.S.R. (4—1 completed and in operation; 1 under construction; 2 not shipped and now held by War Assets Administration). *1947,* Leonard Refineries, Inc., Alma, Mich. (1); Lion Oil Co., El Dorado, Ark. (1); Continental Oil Co., Denver (1—under reconstruction, 1948); Socony-Vacuum, Casper, Wyo. (1); Petrol Terminal Corp., Texas City, Tex. (1—acquired plant built by Government and originally operated by Southport Petroleum Co.). *1948,* Cie. des Produits Chimiques et Raffineries de Berre, Berre, France; Tide-Water Associated Oil Co., Drumright, Okla.

Houdry Process Corp. has the following officers: David N. Hauseman, president; Claude C. Peavy, T. Ellwood Webster, and C. G. Kirkbride, vice-presidents; John D. M. Hamilton, secretary; George H. Daft, treasurer and comptroller; Robert H. Andrews, assistant treasurer and assistant secretary. Board members are: Daft, Hamilton, Hauseman, Kirkbride, Alan T. Knight, Peavy, Pierre M. Quilleret, and Webster.

CHAS. L. HUISKING & CO., INC., really began on Jan. 10, 1898, when Charles L. Huisking, a lad of 13, became office boy for Thomas M. Curtius, a drug broker in N. Y. City. On Jan. 1, 1910, Huisking, at the age of 25, became the youngest drug broker when he opened his own office at No. 3 Burling Slip, N. Y. City. In 1913 the business was moved to 5 Platt St., which had been purchased from the estate of Thomas M. Curtius. A short time later the building at the rear, 110 John St., was added.

During the frantic days of World War I, the huge demands for drugs, chemi-

cals, essential oils, botanicals, and other raw materials which poured into 5 Platt St., were successfully met due to Huisking's wide circle of friends among the manufacturers and the confidence they had in him. While the conflict raged, Charles Huisking made two trips to Europe and handled large shipments of essential materials. In 1917 the business was incorporated as Chas. L. Huisking, Inc., with Charles L. Huisking, president; his brothers George P. and Joseph A., secretary and vice-president, respectively; Peter A. Dirr, vice-president; and William J. Dawson, treasurer.

Following the war, the Company changed from a brokerage house to an agency, commission merchant, and trading business in drugs, chemicals, and allied products. Visualizing the continued importance of exports, Latin-American and foreign shipping departments were created. On Mar. 15, 1920, a London office, Chas. L. Huisking Ltd., was established to carry on general drug and chemical business throughout Europe, which was combined in Mar. 1924 with the old-established firm of Henry Wheeler & Son, as Wheeler & Huisking Ltd., and exists as such today.

As a leading importer of cod liver oil—originally on a commission basis as an agent for one of the largest producers of Norwegian oil—Huisking Co. in 1927 obtained exclusive sales rights in this country of Peder Devold Cod Liver Oil, produced at Aalesund, Norway. Subsequently the Peder Devold Oil Co., Inc., was established and on Nov. 1, 1946, became a division of Huisking. Cod liver oil was at first used primarily for medicinal purposes, but with the development of vitamins the Huisking Co. capitalized on the high vitamin content of its oil and was one of the first to offer it to the poultry and animal-breeding industries. During World War II it was the primary source of cod liver oil, and in view of its ability to maintain adequate stocks, Huisking was instrumental in maintaining prices well below the high levels of World War I. As a result of his efforts in the development of Norwegian cod liver oil, Charles L. Huisking received from the King of Norway on May 28, 1935, a knighthood in the "Order of St. Olav."

In 1918 the Huisking Co. became one of the three distributors of the Italian Conti Castile Soap, and in 1924 the Conti Products Corp. was organized with Charles Huisking as president. The corporation developed many soap specialities, including shampoo, liquid shave, complexion cream, and olive oil, all largely distributed through the drug industry, with foreign sales handled by Huisking.

Until 1930 practically all the santonin consumed in the United States was imported, and due to increasing demands, Huisking became interested in producing it in this country. Consequently an Artemisia—the plant from which santonin is obtained—plantation was developed and today the firm is the sole producer of American santonin. The importance of this development was fully realized during World War II, when the U. S. Government became a large consumer of santonin for use among the Armed Forces in the Middle and Far East.

The outbreak of hostilities in the Far East in 1941 created a serious shortage of menthol when shipments of Chinese and Japanese brands were curtailed. Brazil became a new source of supply and due to the arrangements made by the Huisking Co. with one of its largest menthol producers, the requirements of the American consumers were taken care of successfully. The Huisking Co. handled Japanese camphor on a large scale until du Pont introduced synthetic camphor and in 1936 appointed Huisking one of its two distributors for U.S.P. tablets and powder.

The firm in 1931 moved to new offices and warehouses at 149-155 Varick St., New York, and the next few years acquired additional space at 143-147 Varick St. Nov. 1935, a branch office was opened at 561 E. Illinois St., Chicago, by George P. Huisking, who died the following year and was succeeded by R. H. Roane, its present manager.

The second generation of the Huisking family became associated with the firm when Charles L. Huisking's second son William W., and fifth son, Richard V., entered the business in 1934 and 1939, respectively. The founder still remains very active as president and all the officers have been associated with the firm for a number of years: Peter A. Dirr, vice-president (1911); William J. Dawson, secretary (1915); John J. Lantz, vice-president (1916); Kurt A. Koehler, treasurer (1916); William M. Rothenbusch, vice-president (1921); Hans Sammer, assistant secretary (1923); Oscar Hoenicke, vice-president (1924); and Walter H. Farley, assistant treasurer (1935). After 37 years, Chas. L. Huisking & Co., Inc., enjoys an excellent reputation throughout the world. It has agents in almost every market, and in New York acts as resident buying agent for wholesale druggists and manufacturers in all parts of the world.

HYNSON, WESTCOTT & DUNNING was founded 60 years ago by men realizing the need for an ethical pharmacy which would dispense drugs and prescriptions accurately, use only the finest materials, and provide the medical profession with preparations and services not elsewhere available. The principals were not only fully qualified pharmacists, but lectured at the School of Pharmacy at the University of Maryland and were able to recruit their staff from most promising young men. The pharmacy soon acquired an excellent local reputation and many staff members of the Johns Hopkins and University of Maryland Medical Schools were frequent visitors.

The founders, Henry P. Hynson and James W. Westcott, were joined in 1894 by H. A. B. Dunning. After a few years Dr. Dunning's interest in preparing experimental preparations for physicians led to the manufacture of special products, many of which were suggested by medical friends. The history of Hynson, Westcott & Dunning as pharmaceutical manufacturers began at this time.

The early pharmaceutical specialities were biological. Ovarian products came first and then a dehydrated culture of *Lactobacillus Bulgaricus* in tablet form. One of the most important events at that time was the commercial preparation of the dye phenolsulfonphthalein, which led directly to the development of Mercurochrome. The dye was synthesized by Dr. Ira Remsen in 1889. Subsequent pharmacological and clinical study of the material prepared by Dr. Dunning, who originated the commercial process, led to the Rowntree-Geraghty kidney function test. At about that time, Dr. Dunning also prepared, in cooperation with Dr. Geraghty, a mercury compound of the dye which was investigated by Drs. Hugh H. Young and E. G. Davis as a possible urinary antiseptic. Extension of this study by Dr. E. C. White led to the synthesis of Mercurochrome, the process for preparing the soluble sodium salt being worked out by Dr. Dunning. A third compound, the sodium salt of monohydroxymercuridiiodoresorcinsulfonphthalein, known commercially by the trade name Merodicein, was synthesized by Dr. J. H. F. Dunning, son of Dr. H. A. B. Dunning. This compound is widely used in medicine as one of the two active drugs in Thantis lozenges.

Many other diagnostic and therapeutic products have been made available to the medical profession during the past 30 years as a result of cooperative research between the staff and clinical investigators. Dr. Dunning, from the beginning, recognized the importance of research in industry. Within the organization the first step was the establishment of a chemical research laboratory. Pharmacological and bacteriological laboratories were added when interest turned to biological products. Laboratory facilities have been greatly expanded in recent years and research is carried on continuously with independent investigators.

While extending its manufacturing and research facilities, the Company has main-

tained an ethical retail pharmacy. This is largely a result of Dr. H. A. B. Dunning's interest in the advancement of pharmacy as a profession. His part in this work and in developing the Institute of Pharmacy has been recognized over the years by the award of honorary degrees, election to the presidency of the American Pharmaceutical Association, and award of the Remington medal and many other honors. In recognition of his services to chemical research, he was also awarded the honorary LL.D degree by Johns Hopkins University.

The firm's laboratories, in cooperations with Dr. W. H. Howell, developed the first commerical preparation of the blood anticoagulant, heparin. They were also the first to supply ovarian products, phenolsulfonphthalein, and organic mercurial antiseptics. Among recent developments, a new system of preparing sterile chemical and biological ampule products was completed which served as a model for large penicillin plants in this country and abroad.

During the recent war, the Company engaged in a number of research projects with the Army and Public Health Service. The laboratory, for example, developed a sterile dispenser package of sulfanilamide for the Armed Services, which was patented but the rights relinquished to permit other concerns to supply civilian medical requirements. Hynson, Westcott & Dunning also supplied all military requirements of Bal Ampules, which was "secret" until recently disclosed as being 2,3-dimercaptopropanol. "British-anti-lewisite" was developed as an effective therapeutic agent against certain arsenical war gases and has been proved of value in some other types of heavy metal poisoning. Another important research problem in collaboration with the Public Health Service, was the preparation of an antigen for the diagnosis of amebiasis.

A direct result of emphasis on research is that almost all executive positions are held by men with a research background. Business activities are still restricted to the production of therapeutic and diagnostic agents developed in the firm's laboratories fcr professional use, in collaboration with medical investigators and clinicians. There has been little change in management since the beginning. Dr. H. A. B. Dunning, who was at first a partner, became president when the Company was incorporated in 1930, and chairman of the board in 1945. His eldest son, Dr. J. H. F. Dunning, is now president and two other sons, Drs. H. A. Brown Dunning, Jr., and C. A. Dunning, are treasurer and secretary, respectively. The remainder of the executive staff, all under 50 years, have been associated with the Company for 20 years or more.

INDUSTRIAL RAYON CORPORATION began in 1925 as a reorganization of the failing Industrial Fibre Co. and its 2,000,000 lb. rayon plant in Cleveland. The major impetus in the reorganization and subsequent success of the new company was provided by a man who had no previous experience in either the chemical or textile industries. He was Hiram S. Rivitz, a Cleveland businessman, who had retired in 1923 at the age of 40 after a successful career as head of a plumbing supplies firm. Shortly after reorganization began, Rivitz was persuaded by the Company officials to become general manager. He agreed, provided he received no salary and was given full authority to make whatever changes he considered necessary.

Results under the new management were immediately evident. In the first full year of operation in 1926, production of viscose filament rayon increased to 3,400,000 lb. In 1927 the Company reported a net profit of $907,768 after taxes. In this year Rivitz was elected president and the first phase of an expansion program began which was to raise the production to 70,000,000 lb. in 1946. Expenditures in 1927

for new buildings and equipment made possible an increase in production the following year to 4,250,000 lb.

Encouraged by the successes at Cleveland, the directors voted early in 1928 for construction of a second plant. Covington, Va., with a population of about 6,500, was selected and in less than a year the buildings were completed and enough equipment installed to start operations. The first pulp was steeped in the presses, July 28, 1929. The yarn was good from the outset, so four additional machines were put in and within a week marketable yarn was being produced. Production in the first full year of operation reached around 5,000,000 lb., bringing the combined Cleveland and Covington output in 1930 to more than 10,250,000 lb.

This increased production allowed the Company to venture into the knitted fabric field. It was common practice among many knitters to stretch and load fabrics to an extent which impaired the quality. This created considerable discontent among the consumers and seriously endangered the future of the rayon industry. In a move designed to correct this critical situation, Industrial Rayon Corp. established its own Knitting Department at Cleveland in 1931. This was the first integration of yarn and finished fabric manufacture in the rayon industry. In addition to providing a superior fabric, it induced other knitters to readjust their standards upwards. Expansions in production quickly followed and by 1933 almost 5,000,000 lb. of a total production of about 15,000,000 lb. were being converted to cloth.

During this period Industrial initiated an extensive research program which was to lead to the successful development of its world-famous continuous process for the manufacture of viscose rayon. At the head of this program was Hayden B. Kline, a graduate of M.I.T., who joined the Company as a research chemist in 1925. His work speedily attracted attention, one promotion followed another, and in 1930, at the age of 28, Kline was elected vice-president in charge of plant operations. Three years later he was made a director. In 1946 he was elected to the newly created post of executive vice-president and to membership on the executive committee.

In 1930 Kline had inspected an experimental continuous process for the manufacture of cuprammonium rayon in a small plant in New Jersey. Cuprammonium yarn required comparatively little processing after it was spun and therefore could be completely processed on a single reel. In the manufacture of viscose rayon, however, because of the many discontinuous treatments necessary, producers had almost unanimously rejected the feasibility of continuous processing. Kline did not share this viewpoint. He pictured a machine of a series of reels with the yarn passing downward from one reel to another and receiving a different processing treatment at each level. He outlined his idea to Alden Burkholder, a research chemist, and Walter Knebusch, an engineer, and instructed them to spend their full time and energies in developing a continuous-process machine.

The first major problem was that of devising a reel for high-speed processing. After lengthy experimentation, a thread-advancing reel was developed. The next problem was to find a way in which the yarn could move from one reel to another without being broken or handled. This was solved by the use of reels supported at one end, in a cascade arrangement, with the front end of each reel for one stage directly above the back end of the reel below it. A staff of engineers was set up late in 1936 to direct the production of these machines through a wholly owned subsidiary, Rayon Machinery Corp. George P. Torrence, who had just retired as president of the Link-Belt Co., and who returned to that post in 1946, and Richard F. Bergmann, his assistant chief engineer at Link-Belt, were in charge. In 1937 the first

machine was erected at the Cleveland plant. It had 100 spinnerettes and 10 reels for each spinnerette. Rivitz decided to proceed with plans for plant construction.

Additional stock was sold, money was borrowed, and ground was broken in May 1937, for an $11,000,000 plant at Painesville, O., designed for an annual production of 12,000,000 lb. of rayon. A race now developed between construction of the new plant and commercial perfection of the process. In Feb. 1938, when the steel structure was up and two-thirds of the brickwork completed, the last remaining obstacle was cleared by important developments of Louis S. Fryer, then supervisor of plant procedures and since 1944 vice-president in charge of production. Dec. 2, 1938, the first viscose filament yarn to be manufactured by a continuous process came off the machines at Painesville. It was an historic day for Industrial Rayon Corp. The reception accorded this yarn by weaving mills and converters induced the Company to expand the capacity next year to 18,000,000 lb.

With the advent of World War II and the subsequent urgent military need for rayon tire cord, Industrial's research staff successfully adapted the continuous process to the manufacture of high-tenacity yarn for the tire industry. Key figure in this important development was Kenneth M. McLellan, a member of the research staff. Oct. 1942, the War Production Board ordered conversion of part of the Cleveland plant to the continuous process for the manufacture of tire yarn. This plant, using the conventional spool-spinning method, was producing 9,000,000 lb. of yarn per annum and converting most of it into tubular knitted fabrics. The conversion was accomplished by July 1943. It led to the first integration of yarn, cord, and fabric manufacture in the rayon industry.

When a second WPB directive ordered expansion of Cleveland's tire yarn production, the decision was made to transfer the entire Knitted Underwear Cloth Division to Covington, which was completed by July 1944. The area vacated was rebuilt to house additional viscose capacity and continuous-process machines. Other construction included a refrigeration building for plant-wide air conditioning and a new chemical reclaim building. Meanwhile, the WPB in Sept. 1943, authorized a 22,000,000 lb. expansion at the Painesville plant for the production of tire yarn. Production of high-tenacity yarn began in Sept. 1944. Maximum over-all efficiency was obtained by the fullest use of gravity flow and the largest available batch-processing viscose equipment. As 1946 started, the capacity of Industrial Rayon's three plants was estimated at 70,000,000 lb.—about 30 times as much as when the Corporation was organized.

The yarn quality and production efficiency attained by the continuous process had early attracted other rayon producers, but the war and other factors forestalled active negotiations for the sale of foreign rights to the process. Shortly after the war, however, Courtaulds, Ltd., of England negotiated for the purchase of patent rights. The sale was consummated Dec. 1945, giving Courtaulds rights to the process in Europe, Britain, and its dominions. Companies which subsequently acquired rights to the process are located in Cuba, Sweden, Holland, France, Belgium, Switzerland and Italy. This wide acceptance supports the prediction that Industrial's continuous process may some day become standard procedure for the manufacture of viscose rayon throughout the world.

The present officers of Industrial Rayon are Hiram S. Rivitz, president; Hayden B. Kline, executive vice-president; Moses P. Epstein, vice-president, merchandising; Louis S. Fryer, vice-president, production; Frederick L. Bissinger, secretary; William C. Miller, treasurer; Earle V. Batteurs, controller; and George C. Miller, 2d, assistant secretary-assistant treasurer. Besides Rivitz and Kline, the board of directors includes William S. Ballenger, Isaac J. Collins, George M. Humphrey, Carl N. Osborne, John W. Reavis, and Lewis B. Williams.

INNIS, SPEIDEN & COMPANY was first a partnership. In 1816 at Poughkeepsie, N. Y., Nathan Gifford, Howland Sherman, and Aaron Innis established a dyestuff-manufacturing business, largely financed by Innis, a local banker. The factory was located on Wappingers Creek to take advantage of water power and to furnish dockage to sailing vessels bringing in various dyewoods, barks, and like materials from foreign ports for processing.

Following the original founders, George Innis carried on the business until 1885, when Hasbrouck and William R. Innis directed the firm under the name Innis & Co. In 1904 George V. Sheffield acquired ownership, continuing the operations without change of title. In Jan. 1906 the business was incorporated by Sheffield and the Speiden brothers, Clement C. and Marion, who had been connected with A. Klipstein & Co. Innis, Speiden & Co. now embarked on a vigorous program to expand the variety of products offered and to establish branch offices and stock storage in several cities. The dyewood, dyewood extract, and aniline color lines now became secondary. Shortly after incorporation the Company found larger quarters at 46 Cliff St., N. Y. City, which, with the later acquired site at 48 Cliff St., became the home office until 1929, when a move was made to a modern office building at 117-119 Liberty St.

Before 1912 the Company confined itself to the sale and distribution of imported and domestic products. In that year it began manufacturing several specialty items for the leather industry, in a small factory in Jersey City, N. J. This line is now combined with processing and refining vegetable and animal waxes and the grinding and grading of water-soluble gums, in a modern factory in Jersey City.

In 1915 the Company established a subsidiary, Isco Chemical Co., Inc., which built an electrochemical plant at Niagara Falls, N. Y., under the supervision of Eben C. Speiden, its plant manager. In 1932 a merger took place by an exchange of stock, Isco Chemical becoming a division of Innis, Speiden & Co. At the outset production was confined to chlorine, bleaching powder, and caustic soda, to which was later added for a short period carbon tetrachloride. During a critical shortage of potash salts in 1918, caustic potash was manufactured at Niagara Falls until imports again became available from Europe.

Late in 1925 Clement C. Speiden, who had directed the operation and growth of the Company since 1906, resigned his presidency because of failing health. George V. Sheffield, also active from the beginning, suggested that a younger man take over. Director William H. Sheffield succeeded as president and general manager in Jan. 1926. Under his direction the Company resumed the manufacture of caustic potash at Niagara Falls, utilizing imported muriate of potash, until an adequate supply of domestic muriate encouraged expansion of facilities. Carbonate of potash was then added.

The minor manufacture of chloropicrin (Larvacide) was expanded through research to use as a soil fumigant. The Company also became interested in waxes and water-soluble gums, which had been small trade items for some time in the general line. With arrangements for imports made and machinery installed, a vigorous sales effort was launched which developed into an important division of the Company's general business. Instrumental in the sale of silica, talc, and milk byproducts, the Company distributes through various storage locations throughout the country and maintains branches in Chicago, Philadelphia, Cleveland, Boston, Cincinnati, and Gloversville, N. Y.

Present officers are W. H. Sheffield, president and general manager; C. C. Wickstead, vice-president and treasurer; G. S. Hamilton, vice-president and comptroller; E. T. Ladd, vice-president of Isco Division; W. H. Sheffield, Jr., vice-

president and assistant treasurer; R. C. Palmer, secretary. The board of directors consists of W. H. Sheffield, Wickstead, Hamilton, W. H. Sheffield, Jr., E. C. Speiden, T. G. Flavelle, and H. F. Sheffield.

INTERCHEMICAL CORPORATION'S province—organic surface coatings for decoration or protection—embraces such diverse products as printing inks, paints, enamels, varnishes, table oilcloth, wall coverings, textile colors, carbon papers, dispersed pigments, and artificial leather. Its history begins in May 1928, when three ink companies of world-wide reputation joined to form the International Printing Ink Corp., but its roots go back through these companies and others since added, more than a century. Of these ink units, the Queen City Printing Ink Co. (named for Cincinnati, "Queen City of the West") was established in the 1860's and Philip Ruxton, Inc., in 1893. Ault & Wiborg Co., the largest of the three, was founded under that name in 1878, but its history reaches back to 1845, through its absorption of the Queen City Varnish Co.

Levi Addison Ault, young Canadian, coming to Cincinnati in 1876, worked (at first without pay) for a dealer in lampblack, pitch, oils, etc. Ready in two years to start his own firm, he chose printing ink, made from these materials, as a product with possibilities for betterment, and Frank Bestow Wiborg, a Cincinnati friend of Norwegian descent who helped to supply their $10,000 capital, as an equal partner.

Beginning July 1, 1878, in a small building on New St., the business grew rapidly. By 1883 it was doing so well that Ault took his wife on a delayed honeymoon trip to Europe, first of a series of voyages to all parts of the world. These taught him foreign printing developments; they also led to far-flung selling agencies and offices, and adoption of the motto "Hic et Ubique" (Here and Everywhere), which appeared on the Company's coat of arms when it was incorporated in 1891 with a capital of $500,000. Joseph Hart was then general manager. Branches were established in Chicago under Will Armstrong; New York, C. W. and G. S. Brownell; St. Louis, Walter Crane; Buffalo, H. Bart Hawley and Thomas J. Reese; Toronto, Albert C. Ransom; London, C. W. Brownell, Charles H. Ault, Bertrand Russell, and Charles Ferguson; Philadelphia, G. A. Vasel; Buenos Aires and other South American cities, James A. Wheatley; Shanghai and Manila, B. A. Roberts and U. G. Frondorf. There were also, by 1910, houses in San Francisco, Havana, City of Mexico, and Paris.

For bright-colored inks, Ault & Wiborg early began manufacturing its own pigments, many of them made from imported coal-tar dyes. About 1890 it had its first chemist, Rose, a German; then, in succession, two American brothers, Henry and Robert Hochstetter, both of whom had studied in Germany. It was Robert who recognized the possibilities of lithol reds as ink pigments; inexpensive, relatively fast, nonbleeding, bright, they became very popular under the name "U. S. Reds." The Company also developed "Reflex Blues" and many other special colors. It pioneered in lithography, rotogravure, steel die and mimeograph printing, carbon papers, and typewriter ribbons.

The increasing use of lithography and its adaptation to tin printing by the offset process at the begining of this century led to installation of a Litho Supply Department, headed by Eugene Lyon and later by H. B. Hawley, which furnished lithographic stones, grained metal plates, dampening rollers, etc. For similar reasons, about 1905 a Varnish Department, soon housed in a separate factory in Norwood, was established to supply special coatings, lacquers, varnishes, etc., for tin-decorating work. Maurice C. Longenecker was its manager and Charles R. Bragdon, chemical director from 1915 on; it progressed rapidly in specially engineered finishes for metal products.

When World War I threatened the supply of German dyes and intermediates, vice-president Robert Hochstetter (whose name was later changed to Hilton), with a staff of chemists and engineers, directed by L. S. Munson and later A. Brooking Davis, started duplicating the German products. In a few months production was under way on β-naphthol, aniline, Tobias acid, and other intermediates, and a sufficient volume of brilliant colors to be shared with other users. By the end of the war the dye factory far overshadowed the varnish works in whose back yard it had grown up, but during reconversion it had lost money and was sold in 1920 to a syndicate of Swiss manufacturers, becoming the Cincinnati Chemical Works.

The Varnish Department, also expanding, found at this time a new home by consolidating with the Queen City Varnish Co., founded in 1845 and noted particularly for its wood finishes. The plant on Dana Ave., much enlarged, is today the Cincinnati factory of Interchemical's Finishes Division. The Carbon & Ribbon Department, established about 1907 under Robert S. Moore, soon improved machinery for applying to carbon papers and typewriter ribbons the special inks Ault & Wiborg had been supplying to other converters.

Rotogravure printing, introduced to America by the 1912 Christmas supplement of the *New York Times,* deposits ink from the hollows in an engraved copper cylinder, instead of from raised type (letterpress) or from ink-absorbent plane surfaces (lithography). In the In-Tag Department, Maynard F. Holt, Edwin M. Van Dyck, and Earl H. McLeod worked out the new kinds of ink needed. Joined later by Charles Hasely and Walter W. Mock, they perfected grades suitable for high-grade magazine, catalog, and book work.

International Inks, Inc., jointly owned by Ault & Wiborg and Charles Eneu Johnson, was formed in 1922 to combat a sharp rise from 8¢ to 25¢ per lb. in the price of carbon black, suddenly popular in automobile tires. In a plant built on Doremus Ave. in the meadows (now the Newark plant of I.P.I. Division), it made blacks and ink oils from petroleum and coal-tar residues, until falling prices of blacks about 1927, made the process uneconomical. Johnson had withdrawn two years earlier.

Upon Robert Hilton's resignation in 1921, Jesse B. Hawley, secretary since 1918, had become vice-president, James Hamilton treasurer, and C. A. Mansell secretary. The capitalization had risen to $10,000,000. In 1923 a profit-sharing plan for all employees was adopted.

Wiborg, withdrawing about 1906 from active participation in management, found time to write *Printing Ink—A History,* published in 1926 by Harper. Ault had long served as director of several Cincinnati enterprises and chairman of the Park Board. Though saddened by the death of his only son, Lee B. Ault, just as the latter was beginning to lighten his administrative burdens, he carried on actively until, in his 75th year, failing health dictated his retirement. Both he and Wiborg died in 1930.

When Ault & Wiborg was founded, the Queen City Printing Ink Co. was already a strong concern. It had grown out of a varnish business started in 1845 by Joseph DeGolyer at Troy, N. Y. Freight rates hampered his Western business, so Joseph sent his brothers during the 1850's to set up a varnish plant in Cincinnati; it was soon as successful as his own. Watts DeGolyer moved to Chicago, starting his own company there; and in 1862, while Sam and George were in the army, John Rychen, experienced inkmaker and friend of the family, took charge at Cincinnati. To keep busy during the war, he started making Rychen's Excelsior Printing Inks. On returning as civilian, George bought out his brothers' shares, changed the firm's name to DeGolyer & Rychen, and adopted the trade-mark Queen City Printing Inks. Joseph Green, joining the firm in 1871, ran the busi-

ness end; Rychen supervised production. DeGolyer perfected the manufacture of lampblack and developed colored gloss inks, but his most popular success was a quick-drying ink, "H. D. Book Black."

The Queen City Printing Ink Co. was incorporated in 1876. Rychen, last of the founders, died in 1899; Edwin H. Murdock then guided the company till his death 20 years later. A Chicago branch had been established about 1890; Murdock added offices in Boston, Philadelphia, Kansas City, and several smaller cities. E. F. Cheeseman, Rychen's grandson, was acting head of the company from 1919-21, when Joseph W. Viner (now a divisional vice-president and manager of I.P.I's Aniline Department) took charge. During his administration, large factories for Gritless news inks were built at Philadelphia and St. Louis. Under Albert Grunder, chemical director from 1911 on, improvements in carton and parchment inks, and in specialties for food packages, bread wrappers, mail-order catalogs, and college annuals, brought greatly increased business. By 1928 L. A. Ault and Frank Wiborg had acquired a majority of the stock of Queen City Printing Ink Co., which joined then with their own company and Philip Ruxton, Inc., to form the International Printing Ink Corp.

Philip Ruxton, Inc., "Inkmaker to Particular Printers," had been started in 1893 by the man whose name it bore. A nephew of Herman Behr, Ruxton, after working for his uncle's company (now the Behr-Manning Division of Norton Co.) for nine years, bought its Printing Ink Department and launched his own firm, at first a jobbing business with an office at 30 Burling Slip, N. Y. City. In 1896 a factory was purchased in Brooklyn, and the following year Philip's brother William opened a Chicago office. The Brooklyn works burned down in 1902 and to finance purchase of the Averill Paint Co. plant at 247 Water St., Brooklyn, Ruxton incorporated the business; capital, $40,000. With several additions, this has become the main Eastern manufacturing plant of the I.P.I. Division of Interchemical. Ruxton's technical staff specialized in color selection and harmony. One, named Maretta, artist and student of color theories, developed the Margo system and popularized Ruxton artists' colors; later, Arthur S. Allen based similar work on the Munsell system. Ruxton reds sold particularly well.

Branches were established in Boston, St. Paul, St. Louis, Battle Creek, and Cleveland. John M. Tuttle, who succeeded Wm. Ruxton at Chicago, in 1922 was transferred to New York as executive vice-president; Emory C. Andrews, Roderick Smith (now president of the I.P.I Division), and thereafter Sherman Ruxton followed him in the Chicago managership. In 1920, coincident with the purchase of a manufacturing plant in Chicago, the capital stock was increased to $1,500,000. Two years later a much larger Chicago plant was bought at 2211 Elston Ave. Thoroughly rebuilt in 1946, this is still Midwestern manufacturing headquarters of the I.P.I. Division. The Battle Creek plant, bought in 1923 to give better service to the carton industry, is also operating, while the building at 432 W. 45th St., N. Y. City, erected in 1925 to house office and service station, is now Interchemical's Research Laboratories. A. W. Chauncey, James Beckett, F. Jack Jeuck, and H. F. Smith, who joined Ruxton, Inc., during the 1920's now have prominent positions in the management. Philip Ruxton continued as president until his company was merged. He remained on the board of Interchemical until his death in 1945.

Upon its formation, the International Printing Ink Corp. established headquarters in New York. It temporarily retained the individual selling organizations and the 45 domestic branch houses of its three predecessors. Two of the Ault & Wiborg departments were set up as subsidiaries: the In-Tag Co., guided by Earl H. McLeod, Joseph A. Quigley, and Charles C. Hasely; and Ault & Wiborg Varnish Works, Inc., later renamed Ault & Wiborg Corp. First president of the latter

was Bromwell Ault, grandnephew of L. A. Ault, who had joined the department in 1922 and rose to manager. In 1931 he became president of I.P.I.'s Printing Ink Division and later vice-president of Interchemical. At the Varnish Works he was succeeded as president by Joseph R. Esposito, its New York manager and leading salesman since 1914. Mark W. Frishkorn and Joseph G. Morris, grandnephew of Joseph Green of Queen City Printing Ink Co., became vice-presidents; Morris succeeded Esposito as divisional president early in 1947.

In 1930 the printing ink units of the parent corporation were consolidated and duplicating branch offices closed. Old firm names were dropped, except that Ault & Wiborg Co. was continued to handle carbon paper and typewriter ribbons, and a few years later its name was changed to Ault & Wiborg Carbon & Ribbon Co. Leland C. Ball has been president, and Karl Becker and Albert Bollinger vice-presidents of this unit (now Ault & Wiborg's Carbon & Ribbon Division) for a number of years. Ruxton Products, Inc., was set up in Cincinnati to handle the Corporation's artists' color, writing fluid, and show-card color trade; it was sold in 1947 to its manager, Wm. H. Ruxton. The Export Department eventually became a division headed by C. A. Richards.

Research was first actively started by the Corporation on printing ink problems, in 1929, but was temporarily discontinued two years later. However, duVal R. Goldthwaite, who in 1932 succeeded J. M. Tuttle as president, recognized that fundamental studies are essential to progress. In 1934 Dr. Albert E. Gessler, experienced in the chemistry of coal-tar colors and fast-drying inks, became director of new Research Laboratories in the Ruxton Bldg. The staff grew quickly from 25 to over 150 and much special equipment was installed. An early result of intensive, cooperative exploration in the physics and chemistry of coatings was Vaporin, publication ink for web presses which dries instantaneously by heat. First introduced in 1935, a few years later saw it in use on over 300 magazines, mail-order catalogs, and other publications. Many other important contributions have been made to the graphic arts, industrial finishing and organic protective coatings, textile coloring, pigment manufacture and dispersion, and other fields. Holdfast rub-resistant inks, Lithox and Vapolith inks for lithographic printing, Vaposet inks for food wrappers, Polymerin resistant industrial finish, and the Aridye process for pigment-coloring of fabrics are a few of these.

By-products of these fundamental studies have been such publications as *Three Monographs on Color* (1935), prepared with the help of Prof. Arthur C. Hardy of M.I.T., the Laboratories' consultant; and many scientific and technical articles. Studies in rheology by Henry Green's group, leading to the design and building of the "tackmeter" and the "RL viscometer," have proved especially noteworthy. A quarterly journal, *Interchemical Review,* has been issued since the spring of 1942. The Research Laboratories' director, Dr. Gessler, was made a vice-president of the Corporation in 1945.

Aided by these developments, I.P.I. Corp. not only grew in size and volume of business, but branched into new fields. Its original title, never fully representative, was far outgrown and in 1937 was changed to Interchemical Corp.; the printing ink unit (apart from the rotogravure ink section, In-Tag Co.) continued as International Printing Ink Corp. (Recently, most of the subsidiaries have been converted to divisions of Interchemical.) In the same year duVal R. Goldthwaite became chairman of the board; Ernest W. Pittman, president; and Herbert B. Woodman, vice-president and secretary. In Jan. 1947 Pittman became chairman of the executive committee and Woodman, president. A. Wallace Chauncey is vice-president and treasurer; B. Ault, A. E. Gessler, H. J. Hemingway, and J. R. Esposito, vice-presidents; and Francis A. E. Spitzer, secretary. The board of

directors consists of Goldthwaite, Ault, Chauncey, Pittman, Esposito, Woodman, Hemingway, Fred B. Gleason, Clifford F. Stone, Karl H. Behr, and Hobart Rawson.

The Corporation's policy with regard to dry color manufacture has undergone two reversals. The pigment plants of all three predecessor companies were shut down or sold soon after 1928. In 1934 the United Color & Pigment Co. of Newark, N. J., was bought, but several years' experience with it led to a decision to withdraw from the dry color field, and in Dec. 1943 United was sold to the Calco Chemical Division of American Cyanamid Co. Virginia Chemical Corp., a subsidiary manufacturing titanium pigments at Piney River, Va., since 1936, was also sold to American Cyanamid in 1944. Another tentative move led into the field of machinery, with the purchase in 1936 of Chambon Corp., designers and builders of printing and other automatic machines. This arrangement also proved unsatisfactory and the plant, operated under the new name of Champlain Corp., was sold in 1941. But most of the companies which have joined Interchemical since its formation are fundamentally related and have been fully absorbed.

The Cray-Finne Co. of New York, which was added in 1935, was organized in 1918 by Frank W. Cray (now vice-president of I.P.I. Division) and Harry Finne. It not only made the usual printing inks but pioneered in specialties based on new resins and developed the water-color inks used in the Jean Berté process.

One of the four companies which joined I.P.I. in 1936 was the Standard Printing Ink Co., Cincinnati concern founded in 1885 by Frank Ibold and Adolph Dryer, which made typographic, lithographic, and aniline inks. Robert Kuhn and W. Frank Cornell, officials of Standard, are now divisional vice-presidents and district managers of I.P.I., and Edward Kuhn is a district sales manager.

Another was United Varnish Corp., better known as North Bergen Varnish Works, organized early in 1928; it specialized in industrial finishes, particularly for metal decorating. Jules Bauer, its president in 1935, is now a departmental sales manager of Interchemical's Finishes Division.

Third, I.P.I. Corp. purchased 50% of the common stock of Ault & Wiborg Pty., Ltd., of Canada, which had not taken part in the 1928 consolidation.

Fourth was the R-B-H Lacquer Base Co. which in 1929 grew out of the Robinson-Butler-Hemingway Co., an engineering firm established in 1925 in Bound Brook, N. J. Its pigment dispersions, ground to extreme fineness by unique processes, were preferred by many lacquer, enamel, and ink manufacturers to their own grindings. I.P.I., a large customer, needed this skill and R-B-H Dispersions, Inc., became a subsidiary. R-B-H Dispersions Division now carries on sales while manufacturing has been allocated to a separate division. Harry Hemingway, head of R-B-H, was called in 1937 to direct the operations of Standard Coated Products Corp., an Interchemical affiliate. Walter Edgar, experienced lacquermaker, was president for 10 years, then chairman; William J. Rothemich is now active head.

Aridye Corp. was organized in Aug. 1937 to manufacture and sell textile pigment colors. It introduced a revolutionary new process for printing textiles with resin-bonded pigmented emulsions of the water-in-oil type. In four years most printers of cotton textiles in the United States and Canada were using pigmented emulsions under Aridye licenses. Then came a continuous process for pad-dyeing with similar pigmented emulsions. When the war brought military demands for vast quantities of textiles, the Aridye process successfully met them. During the early development of textile pigment colors, Laurence Meads, then Interchemical vice-president in charge of promotion, visualized their possibilities; as president of Aridye Corp., he set up a plant and laboratories in Fair Lawn, N. J. In Jan. 1947 Aridye became the Textile Colors Division of Interchemical, with Meads chair-

man; Norman Cassel, formerly technical vice-president, president; Chester M. Robbins, Henry Young, and Wm. DePass vice-presidents. The Dye Department of this division was formerly Phoenix Color & Chemical Co. of Paterson, N. J., acquired by Aridye in Dec. 1943.

Standard Coated Products Corp. making Meritas oilcloth and Sanitas wall covering, became associated with Interchemical in 1937 and was merged in 1944 as the Standard Coated Products Division. Its predecessor, the Standard Textile Products Co., had grown out of the merger in 1901 of seven smaller manufacturers of table oilcloth and leather cloth. These were Atha & Hughes, founded in 1851; the table oilcloth department (Sunswick Mills, 1867) of Jos. Wild & Co.; A. F. Buchanan & Sons, 1867; Goodlatte Oilcloth Co., 1887; Western Linoleum Co., 1891; Keystone Oilcloth Co., 1896; and Ohio Oilcloth Co., 1898. One of its two subsidiaries in Dec. 1946 became the Wadsworth & Woodman Division of Interchemical. Although established in 1905, this organization traced a connection with the first Maine oilcloth industry of about 1830. The other subsidiary was Cotan Corp., now an affiliate of Interchemical, whose business of manufacturing leather substitutes has broadened extensively in recent years.

Two paint, varnish, and lacquer companies, Murphy Varnish Co. and Scriver & Quinn, Inc., joined Interchemical in 1944. Of the former, the guiding genius for 55 years from its establishment in 1865 was Franklin Murphy, who entered the varnish business by buying control of Thompson Price & Co., founded in 1845. His subsequent purchase of William Tilden & Nephew, a firm which had begun business in 1807 and was making varnishes in Greenpoint, gives the Murphy Co. precedence in age among all Interchemical units. Starting in a small shop in Newark, N. J., near where the present large plant stands, Murphy specialized in fine carriage, car, and furniture varnishes. Henry M. Murphy, younger brother of Franklin, joined the firm in 1878. To him, as probably the first chemist in any American varnish works, is due much progress in standardization and improvement of quality. The manufacture of ester gum, started at a time when most of the meager supplies came from Germany, enabled the company to make paler, more durable varnishes at lower cost. In 1871 growing business prompted the opening of Chicago and Cleveland branches; the latter, Murphy, Sherwin & Co., was closely associated until 1888 with Sherwin, Williams & Co. A public-spirited citizen, Murphy served on the Park Board, in the State Assembly and in other offices, and was Governor of New Jersey, 1902-4. He headed the Murphy Varnish Co., which was incorporated in 1891 with $2,000,000 capital, until his death in 1920.

Becoming general superintendent in 1895, Clarence Bissell introduced centrifugal clarification of varnish. Other leaders in the organization were Murphy's early partners, James J. Barnet and C. D. Ettinger; his son, Franklin, Jr., who, although an invalid, carried on as president and chairman until his death in 1932; Charles J. Roh, who joined in 1900 and worked up to the presidency in 1926; and Paul S. Kennedy, made vice-president in 1926, who first took a job as chemist in 1910. About 1900 Franklin Murphy bought Laute & Dax and renamed it Essex Varnish Co. It operated independently in metal-decorating finishes for many years but was eventually consolidated. Murphy Finishes Corp., its new name within Interchemical, was combined with the Ault & Wiborg Division in Nov. 1945, to form the Finishes Division; Murphy Paint Division was set up for house paints, other architectural finishes, and automotive refinishing products.

Scriver & Quinn, the other company added in 1944, started about 1880 as a sign-painting partnership; later it retailed paint and painters' supplies. Chartered in 1906, the corporation soon began manufacturing these products and was the first Los Angeles firm to make pyroxylin lacquers. C. E. Burge, who joined the com-

pany in 1918, became president after John C. Quinn's death in 1928. In Dec. 1946 the company merged with Interchemical's Finishes Division, the consumer products being allocated to a unit called Scriver & Quinn Finishes.

The Finishes Division was greatly strengthened by its absorption in 1947 of Roxalin Flexible Finishes, Inc. Founded in 1924 as Royalin Flexible Lacquer Co., by Leo Roon, this "Blue Knight" organization outgrew two plants in Long Island City and in 1934 moved to Elizabeth, N. J. It changed its name with broadened service, developing such specialties as Roxaprene, Roxyn, Rincontrol, and Paladin.

Recent extensive activities of the Interchemical Research Laboratories have brought promising developments in nutritional and pharmaceutical chemicals. In 1945 the Biochemical Division was established with new laboratories and a pilot plant in Union, N. J., to work on amino acids. Erwin T. Fritzsching is its president.

During World War II, all Interchemical divisions gave their best efforts to making camouflage colorants and adhesives, flameproofing treatments for textile articles (tents, etc.), resins for waterproofing maps and for insulating proximity fuses, laminated raincoat material, fast-color pigment dyes for uniforms, laminants for cigarette wraps, and all sorts of special inks, paints, and protective coatings for the Armed Forces.

The Research Laboratories participated importantly in the atomic energy (Manhattan) project, contributing advanced electron-microscope techniques; skill in the manufacture and standardization of inorganic powders; and help in dispersion processes. About ten delicate instruments useful in optical measurements bearing on camouflage were developed in a cooperative program with the Massachusetts Institute of Technology and the Louis Comfort Tiffany Foundation. The Black Widow paint for night fighters was among other contributions.

Reconverted now to peacetime operation, Interchemical Corp. looks forward to increasing usefulness. With intelligent, active customer service as its main policy, it strives to carry forward the high ideals of integrity, quality, and helpfulness set for it by its founders.

INTERLAKE CHEMICAL CORPORATION OF DELAWARE originated with a basic idea of Leigh Willard, now its president. Formerly with Allied Chemical & Dye Corp., as president of one of its large subsidiaries, Willard was convinced that *Products from Coal* produced in by-product ovens should be further processed and marketed by the producing companies. Control of basic raw materials, beginning with coal, was of primary importance. Competition in this field being well established and financially strong, it was important that a new company should have experienced management and an assured source of raw materials, as well as adequate financial backing.

The opportunity came when Willard was elected president of Interlake Iron Corp., which had a tar distillation plant that could become the nucleus of a new chemical company. George R. Fink, president of National Steel Corp., had become interested in this idea, and in the summer of 1943, Interlake Chemical Corp. was organized with equal financial interests taken by Interlake Iron Corp., the nation's largest producer of merchant pig iron, and by Great Lakes Steel Corp., a wholly owned subsidiary of National Steel Corp., fifth largest producer of steel. The present board of directors consists of George R. Fink, chairman; Leigh Willard, president; Earl M. Doig, vice-president; Elton Hoyt, 2d, George M. Humphrey, and Severance A. Millikin. T. F. Bell is assistant secretary-assistant treasurer.

The new company started business July 1, 1943, and purchased Interlake Iron Corp.'s tar distillation plant at South Chicago. An acid-naphthalene plant was con-

structed. Tar acids and naphthalene were very important to the war effort and modern equipment for their production was completed early in 1944. At this stage Interlake Chemical Corp. had as *Products from Coal:* phenol, cresols, xylenols, naphthalene, creosote oils and solutions, heavy oils, road tar, and coal-tar pitches. These units have operated successfully since their completion.

Shortage of material and labor delayed expansion and it was agreed that the most expedient method was to buy operating plants that fitted into the program. Late in 1944 Central Process Corp., manufacturers of phenol-formaldehyde thermosetting resins with a plant at Forest Park, Ill., was purchased. The plant processes and formulas had been developed under the supervision of Raymond G. Booty as general manager. The next purchase, July 1945, was of Makalot Corp., manufacturers of phenolic molding compounds with a plant at Waltham, Mass., founded by Viola and Madison M. Makeever, now consultants to Interlake Chemical. Late in 1945 Makalot took over the sale and distribution of benzene, toluene, xylene, water-white solvents, and ammonium sulfate produced by its parent corporations. Through these purchases Interlake now had control of an important series of aromatic chemicals, some already developed, others to be developed further as primary materials for plastics, paints and varnishes, enamels, synthetic rubber, insecticides, dyestuffs, wood preservatives and other miscellaneous chemicals of this type.

Since its inception the Corporation has carried on organized research, now under the direction of Raymond G. Booty and Ellsworth E. Kimmel, in its own laboratories and at recognized industrial research organizations. Its primary aim is to develop further the most promising of the *Products from Coal* to provide a greater diversity of chemicals. Considerable effort has been focused on plastics. Phenolic plastic molding compounds are being studied to improve products and broaden uses. Another phase of current research covers development of phenolic resins used in the plywood, mineral wool and fiber glass, lumber, automotive, electrical, and paper industries. Other resins derived from coal are also being investigated.

On Nov. 1, 1943, Interlake established its executive and general sales office in Cleveland. Branch sales offices are located in Seattle, Chicago, and Boston. Contributors to the growing demand for Interlake's *Products from Coal* include: Harold Weeks, handling coal-tar chemicals; Donald C. Ross, working on water-white solvents and ammonium sulfate; Carl R. Olsen at Chicago, Thomas R. McLaughlan at Boston, and Charles H. Christian at Cleveland.

INTERNATIONAL MINERALS AND CHEMICAL CORPORATION was founded in 1909 by Thomas C. Meadows and Oscar L. Dortch of Nashville and Columbia, Tenn., respectively. Their company was known as the U. S. Agricultural Corp. These men believed that the chemical fertilizer industry offered good commercial possibilities for expansion and that the industry must control its own raw materials. Meadows conferred with Waldemar Schmidtmann, owner of the Kaliwerke Sollstedt Gewerkschaft at Sollstedt, Germany, and later in New York, July 1901, the International Agricultural Corp. was formed. "International" because I.A.C. sold to Sollstedt 50% of this capital stock. In 1942 the name became the International Minerals & Chemical Corp., better to express the character of the expanding business.

The Company followed its theory of control of its own raw materials. Phosphate rock was first purchased from various miners in the Tennessee field. The Company soon acquired phosphate mines at Mt. Pleasant and Columbia, Tenn., and also purchased a number of acidulating plants. In 1913 I.A.C. purchased the Atlas Phosphate Co. which owned the Prairie Pebble and the Florida Mining Companies, both at Mulberry, Fla.

1913-22 were years of mergers and readjustments for International, which purchased, leased, and constructed several plants. Stephen B. Fleming became president in 1913. The entire fertilizer industry had just passed through a bad year, and Fleming and John J. Watson, treasurer, set up a book deficit of slightly over $1,000,000 on June 30, 1913. Keen competition and a desire to stabilize prices brought about a number of mergers, out of which came the so-called "Big Six" companies. International was one of these and supplied a substantial tonnage of superphosphate and mixed fertilizers, as well as phosphate rock. Use of fertilizers east of the Mississippi had nearly doubled in the decade preceding International's organization. This resulted in great expansion in the industry, particularly in the Company from 1909-12, which caused stock accumulations that brought low prices and low earnings.

In 1914 fertilizer consumption increased, as did Company earnings. World War I brought a boom to the phosphate miners, too, and when shipping conditions and strikes curtailed rock exports to Europe, domestic attention was focused on chemical uses for the rock. International became phosphoric acid-conscious and some of the companies (chemical and fertilizer producers) became interested in elemental phosphorous, phosphoric acid, ferrophosphorous, and detergents. It was more profitable to sell sulfuric acid rather than put it into superphosphate. The sales of this acid contributed most of the profit: the Company was pulling itself into sound financial shape. Around 1920 operations at the Florida phosphate mines were revamped. A complete new drying installation was put in at Mulberry, the basis for the modern drying plant. These improvements, together with a vigorous sales policy, gave the Company's profit curve a steady upward swing. That curve is still going up.

When he became president in 1923, John J. Watson reorganized the capitalization to prepare for the years ahead. Unsettled trade conditions, keen competition, and the NRA clouded the period of 1923-33.

In 1936 the Company first became interested in mining potash in Carlsbad, N. Mex. In January it organized the Union Potash & Chemical Co. under Colorado laws and began development work at Union's New Mexico potash fields which were then only core-prospected. International took over mining developments in July 1938. In 1939 the shaft was completed to 925 ft. and in 1940 the shaft was bottomed at 1,000 ft. On Sept. 30, 1940, the first shipment of potash salts was made: langbeinite, a double sulfate of potash and magnesia mined at 800 ft. Sylvite, a muriate of potash, is mined at 900 ft. In 1940 International secured full ownership of all the Union Potash & Chemical assets. It had sold its interest in the Sollstedt potash mine in Germany in 1938, since German restrictions there made it impossible to operate profitably.

The Carlsbad potash plant doubled its original production schedule of 50,000 tons the first year of operation and has since multiplied it fivefold. In 1944 industrial demand slightly exceeded 500,000 tons of potash; in 1946 and 1947, 1,000,000 tons, of which about 80% goes into fertilizers and the balance into chemicals.

The U. S. Government entered the fertilizer industry in 1938 and by 1942 its distribution of superphosphate exceeded 1,000,000 tons, supplied through purchase from the larger fertilizer companies, including International.

The year 1938 marks the beginning of research at the East Point, Ga., laboratory on calcination of superphosphate to produce a fluorine-free product for stock food. This resulted in the perfection of Defluorophos.

The years 1939-47 have been an era of aggressive expansion under Louis Ware, who became president in 1939. In 1941 executive offices were moved from N. Y. City and Atlanta to Chicago to centralize operations. In 1941, also, the fertilizer

industry hit what was then its peak of production, nearly 10,000,000 tons. Dr. Paul D. V. Manning, now vice-president in charge of research, joined International in 1941. Today the Research Division includes eight laboratories, and the Company provides fellowships to 20 universities and agricultural schools for further study. Plans are under way for a new centralized research laboratory at Northbrook, Ill., construction to start in 1948.

During the war, International's products found vital uses: phosphate went into munitions for Allied troops; monosodium glutamate flavored Army rations and lend-lease food; fertilizer helped American farmers grow record-breaking crops; silica gel kept munitions and food shipped overseas from decomposing. In addition, International operated a government magnesium plant at Austin, Tex., which won the Army and Navy "E," as did the Potash Division at Carlsbad.

In 1942 the Company bought the Amino Products Corp. of Detroit, which produced amino compounds from Steffens waste from beet-sugar molasses. Shortly thereafter, the Government curtailed the supply of beet molasses, so research was started for substitutes in 1943 and finally a 75-85% protein wheat gluten adopted. Beet-planting restrictions have since been lifted and in 1947 International completed a $3,000,000 Amino Division plant in San Jose, Calif., in the best beet-growing area.

Events since 1945 reflect a policy of even greater diversification and expansion. A sales office, known as the International Minerals & Chemicals Ltd., has been established in London to handle phosphate sales in Europe. Construction has started on the new Noralyn phosphate mine near Bartow, Fla., and will be completed early in 1948. This mine is expected to produce over 1,000,000 tons of phosphate a year. In addition, the new Achan Mine came into production in Sept. 1946. International's phosphate operations in Florida use powerful electric draglines such as the "Bigger Digger" whose bucket scoops up 32 tons at a time. During 1946-47 several new fertilizer plants were built: dry mixers at Mason City, Ia., and Pensacola, Fla., an acidulator at Hartsville, S. C., and a sulfuric acid unit at the Spartanburg, S. C., fertilizer plant. Land was purchased for a new fertilizer plant at Somerset, Ky., and plans are under way for additional construction in the Potash Division in New Mexico.

In its divisions today, International has increased from a single product to: plant food—complete fertilizers, superphosphate, multiple superphosphate, sulfuric acid, defluorinated phosphate, silica gel, sodium silicofluoride; potash—muriate of potash, sulfate of potash, sulfate of potash-magnesia, stock salt, and potassium chlorate; phosphate—Florida pebble phosphate and Tennessee rock; amino products—amino acids, monosodium glutamate, glutamic acid, glutamic acid hydrochloride, betaine, betaine hydrochloride, and animal-feed supplements.

The Company is organized into operating divisions, each in charge of a vice-president. Officers include: president, Louis Ware; executive vice-president, James P. Margeson, Jr.; vice-president, Plant Food Division, Harry B. Baylor; vice-president and treasurer, Robert P. Resch; vice-president, Phosphate Division, Franklin Farley; vice-president, Research Division, Dr. Paul D. V. Manning; vice-president, Amino Products Division, J. R. T. Bishop; general counsel and secretary, Edward D. McDougal, Jr.: comptroller, Carl F. Husen; chief engineer, James A. Barr; and general manager, Potash Division, A. Norman Into.

C. E. ISING CORPORATION'S founder, Carl Eugen Ising, was born in Gummersbach, Germany, in 1880, of an old family long identified with industry and mining. Upon the deaths of both parents, he emigrated to the United States and shortly thereafter went into business in New York with a boyhood

acquaintance, Carl Schaetzer, later president of Compagnie Morana (now van Ameringen-Haebler, Inc.). The two young men manufactured synthetic perfume oils and aromatic chemicals for a time. Then Ising withdrew to found his own firm, Chas. E. Ising, which specialized in perfume oils of individual character and aromatic products.

In 1918 the business was incorporated as the C. E. Ising Corp. to manufacture various cosmetics, disinfectants, deodorants, aromatic chemicals, and some Ising specialties; also masking odors for rubber, paper, glue, leather, etc. At first the offices were in N. Y. City, the factory in Flushing, N. Y., but as the business increased both were concentrated in Flushing.

During the first World War, Ising felt strongly that this country should not be dependent upon Europe for its flower oils and he looked to Southern California as a possible source of rose oil and orange oil. He visited Europe, collected data and blueprints for stills and distilling apparatus, and in 1933 went to Southern California to look the field over. He collaborated with the late Dr. H. J. Webber of the University of Southern California and with a staff of university students made an exhaustive research on oil of orange flowers in the orange groves of J. Ralph Shoemaker of Claremont, Calif. It was demonstrated beyond question that a new flower oil industry could be established. Ising then began research on rose oil at Hemet, Calif., where the Howard Rose Co. placed at his disposal several hundred acres of roses of various species. Ising's work here, too, was most convincing and he returned to Flushing and arranged for A. H. Killen, the Company's research chemist, to carry on the work. But Killen was killed in an automobile accident shortly before his proposed trip to California and the project awaited the advent of a skilled chemist with vision for the work to be done. G. A. Pfeiffer of William R. Warner & Co. was much interested in the work and gave Ising valuable assistance.

It was Ising's intention to return to California and put his work on a commercial basis. He gave the results of his research to Dr. Joseph von Degrazzia, research chemist of the Corporation, who had returned to Austria as a government employee and had the work published, which attracted considerable attention. Upon his death, Jan. 1943, Ising's widow, Alice Moore Ising, inherited the business which she continues in the traditions he had established.

JEFFERSON CHEMICAL COMPANY, INC., was formed by the Texas Co. and American Cyanamid Co., Nov. 1944, to manufacture chemicals from petroleum hydrocarbons, including ethylene oxide and ethylene glycol.

As soon as sufficient information had been obtained from pilot plant and market studies, a plant was erected on a site of approximately 1,100 acres near Port Neches, Tex., adjacent to the Texas Co.'s asphalt plant, with some 5,000 ft. frontage on the Neches River. This site was selected because of its proximity to the Texas Co.'s refinery at Port Arthur, from which Jefferson obtains refinery gases as raw material; excellent facilities afforded at Port Neches for water and land transportation; a ready supply of fuel and power; and the quality of labor available. Simultaneously, American Cyanamid Co. purchased an adjoining tract of about 900 acres, and announced plans for erecting a plant of its own to use certain of Jefferson's products as raw materials.

Jefferson's officers and directors were drawn from the Cyanamid and Texas organizations. The initial board of directors consisted of W. S. S. Rodgers, H. T. Klein, and M. Halpern, respectively chairman of the board, president, and vice-president of the Texas Co.; R. J. Dearborn and W. M. Stratford, president and vice-president of Texaco Development Corp.; W. E. Kuhn, manager, Technical & Research Division, Texas Co.; W. B. Bell, president of Cyanamid; K. F.

Cooper, H. L. Derby, R. C. Gaugler, and M. C. Whitaker, vice-presidents, and L. C. Perkinson, treasurer of Cyanamid. Derby resigned as president and director of Jefferson in 1946, and was succeeded by P. M. Dinkins, previously vice-president and general manager. Max Neuhaus, manager, Technical & Research Department, joined Jefferson in 1944, when L. P. Scoville became chief engineer. William H. Bowman, manager of sales, came to Jefferson in 1945, and A. A. Triska was appointed plant manager at Port Neches the same year.

The Company was organized to operate as an independent entity, with its own research, engineering, production, and marketing units. It set up its laboratory in N. Y. City and pilot plant at Port Arthur, however its plans call for ultimate centralization of both activities in a single location. The Company has already embarked upon a broad program of research on the synthesis and use of petroleum-based chemicals, looking toward increasing participation in a rapidly growing field.

JEFFERSON LAKE SULPHUR COMPANY was fathered by a group of businessmen in New Orleans who assembled themselves under the name of the United Oil & Gas Syndicate, incorporated, Apr. 30, 1925. The object was primarily to explore for oil in Louisiana. Mineral leases were acquired by the original syndicate. One of the leases covering the bed of Lake Peigneur in Iberia Parish, was acquired from the state of Louisiana. Of the original directors, three—Adolphe D'Aquin, S. J. T. Hardy, and W. B. Sirera—are members of the board of directors of the present successor corporation.

Several wells were drilled by the Syndicate without success. This corporation transferred all of its leases, assets, and liabilities to the Jefferson Oil & Development Co. and the new company continued drilling operations but failed to discover oil. On July 24, 1928, the present corporation, under the name of the Jefferson Lake Oil Co., Inc., was organized with an authorized capital of 25,000 shares of no-par value stock at $10 per share. The name was changed to Jefferson Lake Sulphur Co., Inc., by amendment to the charter on Feb. 17, 1940. This corporation acquired the mineral leases, assets, and liabilities of the Jefferson Oil & Development Co., and continued to search for oil. Instead of it, however, sulfur was discovered in quantities which indicated a commercially workable deposit under the Lake Peigneur property. Production of sulfur by the Frasch process was started in Oct. 1932. The property became depleted about June 1936, after producing 426,235 long tons of sulfur. The Company then drilled several oil wells on it, but failed to produce oil in commercial quantities.

In 1936 leases were acquired on Clemens Dome, Brazoria County, Tex., and exploration wells drilled that fall proved the existence of sulfur which could be commercially mined. The sulfur-mining plant and facilities were moved from the Lake Peigneur property and production began on May 3, 1937, and is still continuing. The Company also acquired sulfur leases on the Long Point Dome, Fort Bend County, Tex., and after proving the presence of sulfur in commercial quantity, erected a modern and complete sulfur-mining plant and commenced production on June 7, 1946.

The domestic business of the Company is carried on through its own sales organization, dealing directly with the consumers or users of sulfur. Foreign business is done through agents appointed in various countries on a commission basis.

In 1942 research work was commenced in gas chemistry. This resulted in the Company securing from the War Production Board, Nov. 1944, permission to construct a carbon black plant using an improved method. Now in operation, this plant is capable of making two types of carbon black, S. R. F. (semi-reinforced furnace)

and H. M. F. (high modulus furnace), the latter, the nearest approach to channel black.

The directors of the Company are: Adolphe D'Aquin, chairman; Eugene H. Walet, Jr., president; Samuel J. T. Hardy, vice-president; Roger J. Barba, Sr., treasurer; William B. Sirera, Joseph Mullen, and Michael J. Deutch. The other officers are: Charles J. Ferry, secretary, and Leopold L. Lassalle, controller.

JOHNS-MANVILLE CORPORATION traces its origin to 1858 when H. W. Johns, roofing manufacturer and founder of the asbestos industry, started as a jobber and manufacturer in a small shop at 78 William St., N. Y. City, under the name H. W. Johns Manufacturing Co. The first products were roofing made from rag felt and coal tar, and paints and coatings for roofs, metals, wood, and fabrics. In 1868, after long experimentation, the Company began manufacturing products composed wholly or in part of asbestos, many of which became standard for mechanical, structural, and electrical uses. By 1886 it had four departments: paints, roofing, insulations, and asbestos fiberizing and textiles.

While Johns was experimenting with asbestos, Charles B. Manville and his three sons were pioneering in other industrial fields and in 1886 founded the Manville Covering Co. in Milwaukee. The early days of the Manville Co. were largely occupied in discovering the best materials for covering boilers and steam pipes. Mixtures of paper pulp and blue clay, common around Milwaukee, were tried successfully. Later, wool-felt shoddy was substituted for pulp.

Rapidly changing production methods in industry demanding higher-temperature insulations, the Manville Co. took over the Johns Co. branch in Chicago handling asbestos products. In 1901, three years after Johns' death, Manville merged with the Johns Co., under the name of H. W. Johns-Manville Co. When T. F. Manville, president, died in 1925, the Company began a transition from limited to widespread public ownership, and in 1927 became known as Johns-Manville Corp. It inherited a line of insulating cements, asbestos and asphalt roofings, asbestos paper, high- and low-temperature insulations, and other specialties, some of which have been eliminated but many others improved.

Organized research first started in 1916, when a conductivity laboratory was built at the Manville, N. J., plant. Today this is the largest and best-equipped laboratory of its kind in the world, the research being primarily concerned with the control of heat, motion, and sound, and protection against fire, weather, and wear by use of fibrous materials, the most important of which is asbestos from the Company's huge mine in Canada. Other fibrous materials utilized include rock wool (fiberized slag and rock) and wood pulp.

Much production is devoted to products of asbestos fiber and Portland cement. In 1907 Johns-Manville began making rigid asbestos shingles at Nashua, N. H., where it has a plant today. It developed the dry process for manufacturing asbestos shingles in which colored granules can be imbedded, and also produced Transite, a homogeneous asbestos and cement structural sheet formed under hydraulic pressure. Chemstone, Ohmstone, and Asbestos Ebony are variations of Transite, with resins and other impregnants, which make a waterproof sheet resistant to alkalies and acids. Marinite is an asbestos-cement material for fireproofing ships; Flexboard, another for waterproof wall coverings.

Company research has worked out equipment for testing and processing asbestos to meet specific requirements, such as textiles, heat insulations, papers and millboard, etc. It has discovered means of commercially employing short asbestos fibers formerly thrown away. Johns-Manville is a leading factor in the manufacture of asbestos textiles for a wide variety of uses and employs asbestos in exten-

sive lines of heat insulations. In 1945 it announced an entirely new kind of asbestos paper, Quinterra paper, which can be made as thin as cigarette paper yet will not burn. Quinterra is a remarkably efficient insulator for electric apparatus and conductors, and has many other uses.

Acquisition in 1928 of the Banner Rock Products Co. of Alexandria, Ind., early manufacturers of rock-wool insulating products, added new scope to Johns-Manville's activities in supplying insulation for the building, refrigeration, and transportation industries. In 1939 Johns-Manville entered the wood fiber or insulating board business with a plant in Jarratt, Va., using for the first time Southern shortleaf pine. In 1947 a second plant was built in Natchez, Miss.

Johns-Manville's activities in the roofing, floor tile, packing, and friction material fields involve such organic materials as asphalt, rubber resins, and plastics.

In 1928 Johns-Manville purchased the Celite Co., which owned a deposit of diatomaceous earth in Lompoc, Calif., the largest known source of its kind and quality. From that time, the Company greatly increased the range of filtration applications to the varnish, dry cleaning, wine, beer, wort, heavy viscous products, gums, kelp products, pharmaceutical, water-beet sugar, whisky, Rectin, streptomycin, and penicillin processing industries. It also increased the filtration particle size capacity of Celite powders sevenfold. New filler applications include paint and protective coatings, catalysts, plastics, modern polishes, and insecticides.

Johns-Manville's interest in the field of scientific sound control and acoustical treatment dates back to 1911. In addition to materials, it has contributed acoustical engineering practice, solving many sound problems which involved little or no application of Johns-Manville materials. A large acoustical laboratory is maintained.

In its research laboratories near Manville, N. J., the Company employs several hundred scientists and technicians. The new Research Center at this location, whose construction began in 1945, will provide the largest research facilities in the world devoted to building materials, insulations, and allied industrial products. Planned as a group of five buildings on 93 acres, the Center will have 15 experimental factories in two buildings where projects initiated in the research laboratory may be carried through their development and pilot-plant production stage.

KAY FRIES CHEMICALS, INC., was founded in 1930 to carry forward the businesses of Kay Laboratories, Inc., pioneers in the oxidation of oil, and of the Fries & Fries Co., makers of synthetic aromatic chemicals and plasticizers.

Kay Laboratories was the outgrowth of the Kay Research Co., organized by Alfred G. Kay, head of a Pittsburgh brokerage firm, in 1925. Through his hobby, chemical experiments, he became associated with Dr. Joseph H. James of the Carnegie Institute of Technology. Dr. James had invented the James process for oil oxidation, which had passed the laboratory stage and was ready for experimental plant operation. The Kay Research Co. was formed and an experimental plant and laboratory established on Neville Island, near Pittsburgh. The Company began the commercial development of greases, resins, soap, fatty acids, insecticides, and lacquer solvents, based on Dr. James' patents. In spite of other desirable properties, these products were rejected universally because of their objectionable odor.

As often happens in chemical research, one of these oxidized oils turned out to be an excellent denaturant for alcohol. It met a need for a special denaturant for completely denatured alcohol Formula #5 generally used for anti-freeze purposes, at a time when the Prohibition Enforcement Bureau was having considerable difficulty with bootleggers reclaiming anti-freeze alcohol. Kay was asked to produce this denaturant, called aldehol, in sufficient quantity to supply the demand of 3,000

gal. a day. Kay Laboratories, Inc., was formed as the manufacturing company and ground was broken at West Nyack, N. Y. By the end of four months a plant was in production, the first commercial shipment being made Feb. 1, 1927. There were many problems, however the process was finally worked out and a constant supply of aldehol was made available.

During the time aldehol was produced, intensive research was being maintained out of which came an insecticide activator named Penetrol, which was a carrier and spreader for pyrethrum, nicotine, and, later on, rotenone, and other poisons. Some diversification program that would lead into products other than oxidized oils became increasingly necessary. The Company had an excellent staff and was financially able. It bought the assets of the old Fries & Fries Co. of Cincinnati, thereby expanding into the manufacture of aromatic chemicals, intermediates, fumigants, and plasticizers for cellulose acetate. Kay Fries Chemicals was therefore formed and a modern plant built at West Haverstraw, N. Y., to house the new manufacturing activities, as well as the old oxidized oil processes.

This proved to be a difficult time for a new company: it was the beginning of the depression which lasted seven years. However, good use was made of this period to improve the Company's basic position. The staff was refined; standards raised; and substantial research devoted to new chemicals for future wants. Particular emphasis was put on pharmaceutical intermediates, such as triethyl orthoformate, numerous derivatives of cyanacetic acid, and benzyl cyanide. This far-sighted policy, as always, paid dividends, and the Company emerged in a sound position to capitalize on better times.

In 1938 the rapidly increasing demand for phenol-formaldehyde resins led Kay Fries to enter the manufacture of formaldehyde by the Synthite process, which had been perfected by Synthite, Ltd., England, a member of the Tennant group of companies. The Company became at that time the third largest producer of formaldehyde in the United States. The country was emerging from the depression and the pharmaceutical intermediates developed by the Company found increased acceptance, while the demand for cellulose acetate plasticizers multiplied.

During the war years, practically all of the Company's products went into war end uses. Kay Fries Chemicals became one of the principal suppliers of intermediate chemicals for the manufacture of synthetic vitamins, not only in this country, but abroad. It was awarded the Army-Navy "E" for its production achievement.

Practically the same staff that was hired by Kay in 1925 now directs the affairs of the Company. J. T. Ames, former vice-president and general manager, is president; W. P. Bitler, former technical director, is vice-president and plant manager; Dr. Leonard Nicholl is research director; M. T. Inman heads technical sales; R. C. Poynton is general superintendent; and K. B. Rowe is treasurer. Alfred G. Kay is still a director.

SPENCER KELLOGG AND SONS, INC., and linseed oil have been synonymous for many years. Although information regarding the early history is meager, it appears that the enterprise started in the mill built by Supplina Kellogg in 1824 near Amsterdam, N. Y., with a daily capacity of two barrels and using the Chuctanunda Creek for water power. During the periods of particularly dry weather, a blind mule provided the motive power. Supplina Kellogg's business prospered and eventually outgrew its rural location. In 1851, two years after his death, it was moved to Amsterdam by his sons, Lauren and John. The older, Lauren, survived his father only five years, but he left a two and a half-year-old son Spencer, destined to become the founder of Spencer Kellogg & Sons, Inc.

At 21 Spencer Kellogg entered the linseed oil business by obtaining a quarter interest in his uncle's company. After six years, he sold his equity and briefly engaged in banking in Des Moines. Linseed oil apparently held too great a fascination for him, so he soon moved to Buffalo, N. Y., and started another oil company under the firm name of Kellogg & McDougall, which was eventually sold to the National Linseed Oil Trust in 1889. Apr. 16, 1894, Spencer Kellogg organized another linseed oil business known as Spencer Kellogg Co., the control of which he retained throughout his business life. As his three sons came of age, they were admitted to the firm and the name was changed to Spencer Kellogg & Sons.

For the first few years the bulk of its production was raw linseed oil, just as it was pressed from the seed without further processing. The removal of oil from flaxseed was not a complex operation, but did require heavy as well as costly equipment with close supervision. After grinding between steel rolls, the seed was "tempered" by heat and moisture. This mash was placed between hair mats in large plate-type hydraulic presses operating at a pressure up to 4,000 lb. The oil was filtered and placed in large storage tanks to settle or age. This basic process continued to be the principal method employed throughout the industry until quite late in the 1930's when the expeller press was developed.

As production increased, the settling of the oil presented difficulties and Spencer Kellogg helped solve the industry's problem of quality and mass production. Although lacking formal training in chemistry, he was the first to apply chemical processing to raw oil to improve its suitability for special uses. He found that blowing air through oil accomplished in hours what had previously required months of ordinary settling. By varying the temperature, the air treatment imparted properties superior to those of the settled raw oil, and this processed oil, called "aged," met with immediate acceptance.

After "aged" came boiled oil. Heretofore, to reduce the drying time of raw oil used in painting, Japan driers were added while heating to very high temperatures. Spencer Kellogg ascertained the active principle of these driers and after further experimenting found that by adding small quantities of manganese and lead linoleates, the drying time was further reduced without darkening the oil to such a degree as resulted from the use of old-type driers. This "boiled oil" dried in 15 hours as compared to four days for raw oil.

Spencer Kellogg saw opportunities to increase the consumption of linseed oil in the chemical industries, so he established a research laboratory in 1909. Almost from the day of its inception, this laboratory paid dividends in additional special linseed oils and it soon extended its investigations into related fields, with the result that the foundations were laid for the production of other vegetable oils.

Successive increases in the capacity of the Buffalo plant brought the total number of presses to 186, making it the largest flaxseed-crushing plant in the United States. Realizing the inadvisability of concentrating too much activity in a single location, Kellogg built additional plants in strategic locations. He selected Minneapolis for his second plant which was started in 1907. Today, thoroughly modernized with the latest type of expeller equipment, this plant has the largest flaxseed-crushing capacity of any single unit in the world, turning out approximately seven tankcars of oil daily. To handle more advantageously the constantly increasing importations of flaxseed from India and the Argentine, a third plant was started in 1909 in Edgewater, N. J., on deep water which permitted ocean-going ships to come directly to the plant to discharge their large flaxseed cargoes.

The Edgewater plant placed the Company in a position to add another important oil to its business. In 1913 it began crushing castor beans from India and later from Brazil. Commonly thought of as a medicinal article, castor oil had attained far

greater importance in the textile industry where it was employed to soften fibers and impart luster to aniline dyes. It played an important role in World War I in the development of a lubricant for high-speed Liberty motors when the Company's research perfected a method of dissolving the oil in mineral oil. It was equally important in the shock-absorbing devices used on all types of heavy military equipment. Today, castor oil enjoys a usage even more diversified than linseed oil.

The disruptions in the fats and oils industry caused by the First World War proved the testing ground for Spencer Kellogg's son, Howard, who had been admitted to the business in 1903, following his graduation from Harvard U. with a bachelor's degree *cum laude*. When the Company incorporated in 1912, Howard became treasurer, a position he held until he was elevated to vice-president, May 1917. On his father's death, Nov. 1922, Howard succeeded to the presidency.

In 1922 the Company's first foreign operation was inaugurated at a copra-crushing plant in Manila. Similar facilities had already been installed in the Edgewater plant to supply the heavy demand for coconut oil for soap caused by World War I, but greater economies were possible if the operations were centered in the country of origin of the copra. Other developments occurred in rapid succession. The Company purchased a fleet of steamships to transport its coconut oil from Manila to the States. It imported Chinawood oil and subsequently acquired its own plant in Hankow, China. Flaxseed storage and handling facilities were established in Buenos Aires and Rosario.

In 1928 a number of domestic plants were added through the joint acquisition of the American Linseed Co. Next, the Company started the manufacture of coconut hard butter, added the crushing of palm kernels, and engaged in the merchandising of grain to utilize its vast elevator capacity during seasons of low flaxseed inventories. Starting on a small scale in the Chicago plant in 1935 when barely 500,000 bushels were handled, the Company, with the addition of its new Bellevue, O., solvents plant in 1947, now has an annual soybean-crushing capacity of approximately 20,000,000 bushels. At the outbreak of World War II, with the exception of Australia, operations touched on every continent either in the procurement of raw materials or in the sale of its products.

World War II presented the vegetable oil industry with critical, complex questions. Abruptly halting its program of expansion, the Company cooperated with Army and Navy in their solution. Methods were developed to change the molecular structure of oils to achieve new superior properties. An outstanding accomplishment was the conversion of castor oil to one closely approaching Chinawood oil. Later, when the supply of castor oil was sharply curtailed, linseed oil was transformed into a worthy substitute. When Argentine flaxseed was shut off, soybean oil was reconstructed to make possible its use as a supplement in linseed oil outlets.

Howard Kellogg relinquished some of his heavy responsibilities on Dec. 9, 1946, when he became chairman of the board, and his son, Howard Kellogg, Jr., was elected president. At this time the Company's business had reached the unprecedented yearly volume of $140,000,000. Sales exceeded 1,000,000 bbl. of oil with just under 500,000 tons of coproducts, oil meal, pomace, soy flour, etc., and there were no outstanding financial obligations except current bank loans. The Company now has six strategically located mills for crushing soybeans, five for linseed, two for copra, one for castor beans, and one for soy flour. It markets as standard products approximately 60 special oils, over 40 of them derived from linseed, which are consumed in the manufacture of paints, varnishes, enamels, lacquers, printing inks, coated fabrics, insulating materials, patent leather, artificial leather, linoleums, soaps, textiles, lubricants, and bakery and confectionery products.

The administrative staff comprises V. A. Acer, vice-president, marketing; Dr.

Alex Schwarcman, vice-president and director of research; T. C. Jewett, vice-president, manufacturing; J. L. Wickstead, treasurer; and H. J. Aldrich, secretary. The chairman, the president, and these officers, together with A. H. K. Clarke and F. C. Trubee, Jr., comprise the board of directors.

KENTUCKY COLOR AND CHEMICAL COMPANY was the result of an idea of Arthur W. Clark to form a partnership with George A. Goodell, and go into the business of making pigments for paints and printing inks. It was 1919 and both men were factory superintendents with years of experience in making dry colors in Chicago, Clark with Heath & Milligan Co. and Goodell with Sherwin-Williams.

Clark investigated the opportunities in several cities in the South and Middle West, and settled on Louisville, Ky. Through the Louisville Industrial Foundation, they met Robert P. and Sevier Bonnie, two Yale graduates just out of the Army and desirous of making some business connection. Thereupon the Kentucky Color & Chemical Co. was organized and incorporated, with Clark, president; Sevier Bonnie, vice-president in charge of sales and advertising; Robert P. Bonnie, secretary-treasurer; and Goodell, general manager of production and research. With Clark and Goodell supplying the technical know-how, most of the financing was done by the Bonnies who owned an abandoned distillery, a spur railroad track, and much equipment which was converted to color production by A. Markham Co.

Production began with the regular dry colors used by the paint and printing ink industries—chrome yellows and greens, reds, blues, and organic lakes—most of which were struck in large 10,000-gallon tanks, Mar. 1920. Robert Bonnie established an up-to-date accounting system, whereby if the cost of any color was out of line, it was referred to the Research Department for investigation. In one spectacular case, Goodell's research resulted in reduction of 3¢ per pound in the cost, and a better product. By-products were recovered from the very start, which prevented contamination of the Ohio River and reclaimed salable greens and blues.

After two successful years, the short but severe depression of 1921-22 caught the Company with a large inventory of finished goods made with high-priced raw materials, contracted for from abroad—many of these unexpired contracts had to be canceled at a heavy loss. But the Bonnies' strong financial resources pulled Kentucky Color & Chemical through. From this point on the output was gradually increased, the plant extended, another story built for office, and eventually another building erected to accommodate the present offices and better equipped laboratories for research, color control, and testing, and a small paint plant installed for customer service.

From time to time the firm considered buying smaller plants, or establishing branch factories, but with the exception of the National Ultramarine Co. of Cincinnati, which was bought, later merged with, then sold to the Calco Chemical Co., it was decided instead to expand the Louisville plant. Here units were installed to produce coal-tar products, emulsions, chromium hydroxide, cadmium colors, as well as a complete line of nontoxic insecticides, A ferrite plant was started, but discontinued for increased production of iron blues. The Company greatly extended and improved its original line of colors, overcoming some trying delays and losses, such as the disastrous flood of 1937. Its contribution to World War II was the production of 2,500,000 lb. of high-purity barium chromate for use as kindling charge in incendiary bombs. Today the Company is the only important dry color plant south of Ohio and ranks fourth or fifth in the industry.

When Clark died in Feb. 1936, Goodell succeeded him as president, and J. D. Todd, who had been research chemist and later production manager, was made vice-

president in charge of production. In 1941 Goodell resigned to be chairman of the board of directors for three years, Sevier Bonnie was elected president, and W. R. Fritsch was promoted to vice-president in charge of sales.

KOPPERS COMPANY, INC., today builds coke plants; operates coke plants and blast furnaces; makes tar products, chemicals, shop and foundry products, and piston rings; treats wood. It is foremost in the world in the coke-oven field. To get a true prospective of the Company, it is necessary to look back to the turn of the 20th century. Then the steel industry was flourishing, but its coke came largely from wasteful beehive coke ovens.

The United States Steel Corp. learned that a German scientist, Dr. Heinrich Koppers, had invented a new oven which not only produced 1,500 lb. of coke from each ton of coal carbonized, but also recovered many valuable by-products. It sent a group of engineers to Essen in 1906 and invited Dr. Koppers to come to this country to design and supervise construction of a battery of his ovens for a plant of the Illinois Steel Co. at Joliet, Ill. Dr. Koppers arrived in 1907, established a branch of his engineering firm in Joliet, and began to build a battery of by-product coke ovens. By 1912, when the H. Koppers Co. was incorporated in Maine, it had established headquarters in Chicago and was building coke ovens for a number of steel companies.

The tremendous possibilities in the by-product coke-oven field were foreseen by a group of Pittsburghers headed by H. B. Rust, and in 1914 they bought a major interest in Koppers and next year moved the 85 employees to Pittsburgh where the headquarters have remained. Rust became president (till 1929) and the firm name changed to H. Koppers Co. (Pennsylvania). Dr. Koppers (died 1941) returned to Germany many years ago and the Company has been owned entirely by American stockholders since 1918, when they purchased from the Alien Property Custodian the 20% enemy interest and changed the name to the Koppers Co.

During World War I the Company put into operation an average of one complete coke plant every 60 days: the by-product coke capacity of this country was doubled. After 1918 the Company entered many related fields. It purchased and developed coal mines, ship lines, shipbuilding yards, a steel company, a railroad, and gas companies, but all of these operations have been sold or are conducted by an associate company.

In engineering and construction, the outstanding developments made by Koppers between World Wars I and II are (1) first coke ovens to be heated with producer gas in the United States; (2) Becker-type ovens providing 50% bigger coking capacity; (3) pioneering of liquid processes for removal of hydrogen sulfide from gas; (4) first coke ovens heated with blast-furnace gas in this country; (5) Koppers-Becker low-differential ovens streamlining gas flow in combustion chamber; and (6) first under-jet ovens with waste-gas recirculation.

Again in World War II, Koppers designed and built a large number of coke and other plants. It designed, built, and operated at Kobuta (Monaca), Pa., a huge synthetic rubber raw material plant. Following the war, Koppers purchased the styrene-manufacturing facilities of this plant from the War Assets Administration and now operates them as part of its Chemical Division.

Koppers has been refining crude tar from coke ovens since 1920. Today it refines about one-fifth of this country's production, in 16 plants. It operates a plant for refining naphthalene and producing moth balls, disinfectants, insecticides, and candles. Another plant applies protective coal-tar pitch coating to corrugated steel sheets and three others make protective coatings for pipe lines and other equipment. Koppers tar products plants process about 160,000,000 gal. of crude tar

yearly, 80% of which becomes road tars, wood preservatives, roofing materials, pitch, and pitch coke. The remaining 20% ends as naphthalene, light oil products, tar acids, tar bases. A small part (by volume) becomes pure chemicals.

The large amount of creosote oil refined from coke-oven tar suggested entry into the wood-preserving business. In 1930 Koppers bought the Wood Preserving Corp. with its 18 treating plants and now operates 22 plants extending from Maine to Colorado to Texas. Timberlands owned by the Company produce part of the lumber for treatment and some customers, such as railroads and telephone companies, furnish their own wood for treatment. About 65% of its wood-preserving sales are to railroads. Koppers also sells untreated forest products. In addition to creosote treatment, it has developed a resin and a salts treatment for preserving wood, as well as a fire-retarding treatment.

Koppers owns and operates a large coke plant at Kearny, N. J., and another in St. Paul, Minn., which produce coke, gas tar, ammonium sulfate, and light oils. The gas is sold to public utilities, the coke to domestic and industrial users. A wholly owned subsidiary also operates a blast furnace and coke ovens at Granite City, Ill.

The recently established Chemical Division plans to expand considerably in production of synthetic organic chemicals and ingredients for plastics. At Kobuta, Pa., it operates a plant producing styrene and polystyrene, and a phthalic anhydride plant. A new chemical plant has just been completed at Kearny. In 1947 Koppers entered the chemical field even more strongly with purchase of virtually all the outstanding stock of the Pennsylvania Coal Products Co. at Petrolia, Pa., and outright purchase from the Defense Plants Corp. of a 100-octane gasoline refinery at Oil City, Pa. It is planned to expand both output and products at the Petrolia plant, now making resorcinol, resorcinol resins, sodium sulfite, catechol, and other fine chemicals. The Oil City plant, operated by the Pennzoil Co. during the war, is being converted to alkylated cresols and phenols. Late in 1947, Koppers purchased the Manufacturers Chemical Corp. of Berkeley Heights, N. J., and its sales subsidiary, the Chemaco Corp. Both are now operated as part of the Koppers Chemical Division. This plant compounds and colors plastics, including polystyrene, ethylcellulose, and cellulose acetate.

In 1928 Koppers acquired the Bartlett-Hayward Co. producing gas plants, gas holders, and other equipment since 1832, and later merged its Western Gas Construction Co. with it. Now part of the Metal Products Division, the plant produces gas holders, coke and gas plant equipment, Fast's self-aligning couplings, Koppers-Elec Precipitators, Aeromatic aircraft propellers, and foundry and shop products.

When Koppers Co. was organized in 1914, one of the first acts was to establish a Research Department to study problems in production and utilization of coal, coke, tar, gas, and other by-products. This was located in Mellon Institute under F. W. Sperr, Jr. From 1930-34 the Koppers Research Corp. handled research problems and in 1939 a new Research Department was formed to serve all divisions and affiliates of Koppers, headed by Fred Denig, vice-president and director of research. Among the many fruits of this research are chemicals, paints, varnishes, resins, plastics, processes for treating gas and other by-products, and coke stokers for home heating.

Today Koppers maintains numerous fellowships at Mellon Institute and at colleges and universities in synthetic organic chemistry, in chemicals from coal, and on apparatus for determining the gas and coke properties of coal deposits all over the world.

In May 1946 Gen. Brehon B. Somervell succeeded J. P. Williams, Jr., as pres-

ident of Koppers. Williams, now chairman, became head after the death of J. T. Tierney, second president of the Company, in Oct. 1944.

L. & R. ORGANIC PRODUCTS CO., was organized Oct. 1916 in New York, to manufacture and deal in aniline dyes and other organic chemicals. "L. & R." had to be added to Organic Products Co. because a charter for that name had already been granted to another firm in upstate New York.

The idea of an all-embracing organic products organizations came from one of the founders, David D. Radcliffe; the capital from his prospective associate, Harry L. Lobsenz, a graduate of Columbia University. Manufacturing was started in the rented Lufberry plant at Elizabeth, N. J., where a Dr. Worden had previously made picric acid, but had abandoned it by the end of 1916. With new equipment designed, production of nigrosine was begun and later expanded to include fuchsin, never before made in the United States.

Meanwhile a change had taken place in the organization of the Company. Early in 1917 Radcliffe sold his interest to Lobsenz, who remained as sole stockholder and business manager. A Dr. Tobin was employed at the dye factory whose products were distributed from a small office at 10 Maiden Lane, N. Y. City, which also handled the products of other newly sprung-up dye plants scattered throughout New Jersey, Pennsylvania, and Rhode Island. Lobsenz, soon finding it difficult to handle both the Elizabeth factory and a selling organization, sold the former early in 1918 to Dr. Stuebner, then with Columbia Graphophone Co., a subsidiary of the International Paper Co.

With the termination of World War I, a resurgence of the I. G. made matters very uncomfortable for the young American dye industry. Consumers' resistance to American products required relentless efforts to overcome. Newcomers to the industry helped, but the small, independent manufacturer did his share. L. & R. Organic Products is one of the few organizations of those early days to survive. It has grown to a business of world-wide scope, comprising a complete line of dyestuffs for all industries, with Harry L. Lobsenz still its owner and general manager.

LIBBEY-OWENS-FORD GLASS COMPANY and many great mechanical triumphs in American glassmaking had their start in 1888, when Edward D. Libbey brought to Toledo a group of associates who had worked in his former New England Glass Co. at East Cambridge, Mass., to establish his own Libbey Glass Co. Abundance of natural gas in northwestern Ohio was a big factor in this move. Those were the days of peripatetic plants in the industry. Small-pot furnaces, housed in flimsy structures, moved to the site of cheap fuel, sand, and other raw materials. Workmen and artisans followed.

The Libbey plant manufactured chiefly tableware, some bottles, a variety of pressed and blown items. Michael J. Owens, its superintendent, made a name for himself when he invented the fully automatic bottle-blowing machine and perfected the Colburn machine for flat drawing of sheet glass. Out of the Libbey plant came also the Westlake machine for paste-mold production of tableware, the Danner tube-drawing machine, and numerous developments in glass-melting tank construction, refractories, decorative processes, and fiber glass methods.

Another antecedent of this company was Capt. John Baptiste Ford, a romantic business figure of the antebellum days, who was a saddler, grocer, flour miller, foundryman, steelmaker, and shipbuilder, before he became interested in the production of plate glass in 1868, at New Albany, Ind. By 1870 he had produced commercially the first American plate glass at his Star Glass Co. Later he tried to organize a larger company at Louisville, but lost his capital. At 70 years of age he

raised some new capital in New York and made another attempt at Creighton, Pa., where supplies of coal and sand were abundant. His sons, Edward and Emory, worked along with him in the glass business. Pittsburgh interests helped to finance additional plants and the Company became the Pittsburgh Plate Glass Co.

Captain Ford early saw a solution to the problem of obtaining soda ash and in 1891 bought land at Wyandotte, Mich., where he started the works which became the Michigan Alkali Co. Eventually the Fords sold their interests in the Eastern glass firm and Edward Ford came to Toledo in 1899 and acquired land in the suburbs where now stands the town of Rossford, named for the Ford and Ross families—Mrs. Ford was Carrie Ross. Here was built the largest individual plate-glass plant in the United States and one which has kept in the forefront of technological and mechanical progress. It was incorporated Nov. 11, 1899, as the Edward Ford Plate Glass Co., with Edward Ford, first president and treasurer; John B. Ford, Jr., his brother, vice-president; and Andrew Brymer, secretary. These three with Leonard S. Johnson and Rathbun Fuller, an attorney, were directors.

Captain Ford died in 1903, aged 91. On his 80th birthday, a monument in Ford City, Pa., named for him, was unveiled by George Ross Ford, a grandson, who later succeeded his father as president. It was erected with funds donated by the workers of the Pittsburgh Plate Glass Co.

The Libbey-Owens Sheet Glass Co. was chartered in Ohio, in 1916, to utilize in a plant at Charleston, W. Va., the Colburn machine perfected by Owens and associates. Officers were Edward D. Libbey, president; Clarence Brown, vice-president; Arthur E. Fowle, treasurer; and Charles A. Schmettau, secretary. Directors were Libbey, Owens, Brown, Fowle, and Frederick L. Geddes. In 1912, at Pittsburgh, Libbey through his Toledo Glass Co. had acquired the Colburn patents at auction from a trustee in bankruptcy. Colburn was brought to Toledo to work with Owens and others in perfecting his machine. Between 1912-16 more than $1,000,000 was expended for this. The Charleston plant started production in Oct. 1917. It soon was drawing a sheet wider than the original 45 inches and rapidly expanding in plant. By 1927 the Colburn machine was modified to draw plate-glass blanks.

The U. S. Sheet & Window Glass Co., organized at Shreveport, La., in 1921, was licensed to use the Colburn machine and in 1928 was purchased outright by Libbey-Owens. The Fairfield Sheet & Window Glass Co., Lancaster, O., was another licensee that was also acquired by Libbey-Owens in 1928, but dismantled in 1934.

The rapid growth of the automotive industry, 1920-30, gave tremendous impetus to the plate and window plass industries and brought about strenuous efforts to meet the demand for safety glass. Prior to 1925 Libbey-Owens made nothing but window glass and Ford Plate Glass Co., only plate glass. Automotive demand was such that Libbey-Owens began to make thin plate glass, put in grinding and polishing plants, and was among the early makers of safety glass. Meanwhile, Ford Plate modernized its plant to provide the new glass in demand. It appeared that the two units would complement each other in future developments of safety glass and, therefore, July 1, 1930, the companies were brought together into the Libbey-Owens-Ford Glass Co., tying the three great names in glass into the corporate name. By now these pioneers in glass development had passed on.

The far-reaching and revolutionary mechanical changes which had come about in the plate and window glass industries in the two decades had largely emphasized glass as a physical product. But the requirements of machines, for day-after-day performance to high standards of quality in the final product, brought

the chemist into the picture in the decade 1910-20. Research was undertaken by Libbey-Owens-Ford as early as 1919. Today there are chemists in each individual plant controlling important processes and materials. The glass research and technical facilities are housed in a special Technical Building manned by 130 technicians, many of them specialists. David H. Goodwillie, executive vice-president, heads the manufacturing research, engineering, and technological operations. The research staff includes Dr. George B. Watkins, director; Dr. Joseph D. Ryan, Donald E. Sharp, and Dr. Roy W. Wampler, assistant directors. In addition to glass technology, the program includes engineering research in connection with glass manufacture and plastics research in connection with manufacture of safety glass.

Safety glass was invented in 1905 by John Crew Wood, an Englishman, who used Canada balsam for cementing transparent Celluloid between two sheets of glass. Patents lapsed because of poor quality of product, high cost of materials, and small demand. In 1910 a French chemist, Bénédictus, obtained patents for laminated glass using gelatin for adhesive. In the United States there were three companies making laminated glass during the period of 1914-17. Safety glass became of interest as automotive speeds increased. In 1926 the Libbey-Owens Sheet Glass Co. established a research section of 16 men to work on the problem of producing laminated safety glass in quantities sufficient to meet automotive requirements. Factories to produce plate glass thinner than had ever been made commercially had to be designed and built. A satisfactory plastic had to be developed which would neither discolor nor become brittle with age or low temperature. A bonding agent to render the lamination permanent was also needed. Improvements were made in cellulose nitrate in the subsequent three or four years of the research.

By 1929 a method of laminating glass had been developed by Libbey-Owens using nitrocellulose lacquer as bonding adhesive. The Laminated plant on East Broadway in Toledo was built in that year. In 1930 the autoclave method was adopted in bonding operations; in 1932 Libbey-Owens-Ford introduced cellulose acetate as a plastic interlayer and new plasticizers. By the end of 1934 the search for better plastic interlayers had brought forth a vinyl resin and within the next four years much Libbey-Owens-Ford safety glass was made with polyvinyl butyral resin plastic, called Hi-Test plastic, which required neither bonding agent nor edge seal. The Company also developed a new plasticizer, dibutyl sebacate, which it patented and freely licensed. Since 1930 there have been many improvements in the technique of manufacturing laminated glass tied in with purely chemical discoveries.

In 1931 the property of the National Plate Glass Co., Ottawa, Ill., was acquired at the time that a contract was made with General Motors Corp. to furnish its requirements of automotive glass. Completely modernized, this property has a continuous production of plate-glass blanks, grinding and polishing lines, and a complete laminated plant.

In 1934, with the aid of chemists, the Company started development of Thermopane, an insulated window unit composed of two lights of glass separated by a dehydrated air space, with the glass lights permanently held by a metal-to-glass bond at the edges. Such a unit, now commercially produced, provides the same insulation as an ordinary, 8-inch brick wall. In 1935 a plant at Parkersburg, W. Va., which was manufacturing Vitrolite, a colorful structural glass, was acquired by Libbey-Owens-Ford. For many years the Company has served as sales agents for ornamental figured glass products of the Blue Ridge Glass Corp., Kingsport, Tenn.

In June 1940, Libbey-Owens-Ford acquired the majority interest in Plaskon

Co., Inc., and in Apr. 1943 the balance, whereupon Plaskon was merged as the Plaskon Division. This wholly owned subsidiary traces its origin to the Toledo Scale Co. On Jan. 1, 1928, Hubert D. Bennett, then president of Toledo Scale, established a fellowship at the Mellon Institute to develop a white, light but sturdy plastic material to replace the heavy porcelain-enameled cast iron then being used in food-store scale housings. Dr. Arthur M. Howald, who undertook the work, developed a urea-formaldehyde cellulose-filled, colorless molding material, which could not be pigmented. In 1930 a subsidiary, Toledo Synthetic Products, Inc., was set up to manufacture this material, for which the trade-mark Plaskon was adopted and registered. James L. Rodgers, Jr., was named president and Dr. Howald came from Pittsburgh to supervise production.

From the beginning, Plaskon molding compound found a ready market, although it was not until 1935 that a scale incorporating it appeared on the market. In 1936 the corporate name was changed to Plaskon Co., Inc., and a merger completed with Unyte Corp., another manufacturer of urea-formaldehyde molding materials, with a plant at Grasselli, N. J. Plaskon Co. developed and made commercially available various other products: urea-formaldehyde hot and cold-setting powdered adhesives; melamine-formaldehyde cellulose-filled molding compounds; low-pressure laminating resins; polyester resins; urea-formaldehyde lacquer resins; etc.

In 1943 the Plaskon Division acquired the Paramet Chemical Corp., Long Island City, N. Y., owners of patents on, and producers of, many alkyd, modified phenolic, and other resins for the paint industry, and renamed it Paramet Corp. The same year, the Liberty Mirror Works, Brackenridge, Pa., manufacturing mirrors by thermal evaporation of metals under high vacuum, was acquired. This is now the Liberty Mirror Division of the Company.

Libbey-Owens-Ford has invested about $18,000,000 in the three postwar years for plant modernization. In 1947 Paramet Corp. was consolidated with the Plaskon Division and the manufacture of its products transferred to a new plant at Toledo. The Grasselli, N. J., molding compound operation was also removed to Toledo, where the Plaskon Division maintains a research staff of 54, under director Dr. Howald. This complete new factory group involved expenditures of over $8,000,000. At the glass plants large outlays have gone into power facilities, a new continuous glass-melting tank at Rossford, extensive improvements at Shreveport, and new construction and extension of laminating facilities at Ottawa. More than $250,000 was spent for enlarging the Technical Bldg. at Toledo.

Libbey-Owens-Ford plants, located strategically in respect to raw materials, markets, and shipping facilities, form an integrated unit designed to take care of the large automotive demand and to provide flexible facilities to supply markets for glass used in building construction, furniture and household appliance industries, mirror trade, and many miscellaneous outlets for plate and window glass.

High-quality window glass is laminated at the two safety glass plants. Some glass made at Charleston is ground and polished for lamination at Toledo or Ottawa. Rossford combines large plate-glass manufacture with several types of specialty operations, including heat-treated glass. Both window glass and plate glass are used in Thermopane assemblies. In most of the interplant relationships the glass moves geographically from areas of abundant raw materials and fuel towards the large markets for finishing operations.

Libbey-Owens-Ford employed 10,176 in factories and offices early in 1947. Total sales for 1946 were $68,349,389. John D. Biggers is president. Other officers include David H. Goodwillie, executive vice-president; George P. MacNichol, Jr., vice-president, sales; Herbert H. Baker, vice-president and secretary; James L.

Rodgers, Jr., vice-president (heads Plaskon Division); L. Glenn Bryan, vice-president, production; Clark E. Husted, vice-president; F. Earle Cazayoux, comptroller-treasurer.

ELI LILLY AND COMPANY was started on May 10, 1876, by Col. Eli Lilly as a small pharmaceutical manufacturing establishment at 15 West Pearl St., Indianapolis, Ind., to supply physicians with quality medicines true to label and of known potency. In 1854 Eli Lilly, while visiting an uncle in Lafayette, Ind., was inspired by the sign of the Good Samaritan hanging over a drugstore to become a pharmacist. Young Lilly became apprenticed to the owner of the Good Samaritan Drug Store, Henry Lawrence, with whom he studied according to the standards of the day for five years. Then followed several ventures into the retail drug business and the intervention of the Civil War, after which Colonel Lilly engaged in cotton planting in the South for several years before organizing his drug company.

In the beginning Colonel Lilly divided his time between manufacturing and selling. Capital, about $1,300 to start with, was so limited that it was necessary to sell one lot before another could be made. In 1880, needing capital to expand the manufacturing facilities, the business was incorporated as Eli Lilly & Co., with Eli Lilly as president and treasurer; James E. Lilly, vice-president; and Evan F. Lilly, secretary. Next year the business moved to the present site on McCarty St. and the first pharmaceutical branch was opened in Kansas City, Mo. In 1884 the ownership became vested in the Lilly family, the predominant owners today.

In 1878 sales reached $30,000 and a sales organization was started with James E. Lilly, the founder's brother, as the first salesman. The Lilly sales policy of selling medicinal products only through the drug trade was adopted in 1894 and led in 1906 to exclusive distribution through the service wholesale drug house. The Chicago branch was opened in 1898, to be followed by the New York and New Orleans branches in 1902; the San Francisco, in 1904.

From a humble, two-story building in which Eli Lilly, pharmaceutical chemist, started business, the Company has grown to an establishment covering ten city blocks, with new production and shipping units being installed on a recently purchased property on Kentucky Ave. in Indianapolis. The world-wide export of Lilly products has led to the formation of Eli Lilly International Corp.; Eli Lilly Pan-American Corp.; Eli Lilly y Compañia de Mexico, S.A. de C.V.; Eli Lilly & Co. of Brazil, Inc.; Eli Lilly & Co. of Argentina, Inc.; Eli Lilly & Co. (Canada) Ltd.; and Eli Lilly & Co., Ltd., Basingstoke, England.

Since the first gelatin-coated pill was introduced in 1877, Eli Lilly & Co. has been developing new and superior medicinal products through research. In 1884 alkaloidal and extractive standards were established and in 1909 empty gelatin capsules introduced. A scientific division for control and research work was organized in 1886 by Josiah K. Lilly, superintendent of the laboratory. In 1882 Josiah, who had helped his father as a youth of 14, had graduated from the Philadelphia College of Pharmacy and returned to the laboratory as assistant superintendent. He became the head of the Company on Eli Lilly's death in June 1898, and served until 1932, when he became chairman.

In 1912 the Company purchased 156 acres near Greenfield, Ind., for a biological laboratory, and entered the biological field in 1915. In 1922, in cooperation with Drs. Banting and Best of the University of Toronto, codiscoverers of insulin in 1921, Lilly introduced the first insulin commercially available in the United States. The first of several barbituric acid products was marketed in 1925. To aid in research, a Clinical Research Department was established in 1930 and the

Lilly Research Laboratories were dedicated in Indianapolis in 1934. During these years liver products were made available to physicians. In 1939 laboratories of Eli Lilly & Co., Ltd., Basingstoke, England, were completed and a new wing was added to the research building in Indianapolis.

In 1941 conversion to wartime production began. Over 200 products were supplied to the Government for war use. Large quantities of penicillin and quinacrine hydrochloride were produced and more than 2,000,000 pints of blood plasma were processed and delivered to the Armed Forces without profit to the Company. The major research was in cooperation with the Office of Scientific Research & Development.

Through the Lilly Research Laboratories, the Company cooperates with colleges and universities in promoting fundamental research and developing new medicinal products. Two grandsons of the founder head the management of the Company: Eli Lilly, president, and Josiah Kirby Lilly, Jr., executive vice-president. Both graduate pharmacists, Eli entered the business in 1907 and his brother in 1914. Vice-presidents head each of the six major functions of the Company: Nicholas H. Noyes, finance; Ralph M. Reahard, production; William A. Hanley, engineering; Earl S. Retter, marketing; Earl Beck, industrial relations; and A. H. Fiske, research.

ARTHUR D. LITTLE, INC., was preceded by a partnership formed on Oct. 1, 1886, by Arthur D. Little, recently out of M.I.T., and Roger B. Griffin, an analytical chemist formerly with the W. M. Habirshaw Co. of New York. Both men had been active in operating the first sulfite paper mill in the United States for the Richmond Paper Co., at Rumford, R. I., just before they started their consulting and analytical laboratory at 103 Milk St., Boston, with $2,500 in capital, of which $2,300 went into equipment. Boston, with approximately 400,000 inhabitants then, had about six men trying to make a living by the commercial practice of chemistry. The early work was largely analytical; a great deal of sugar came into Boston; nitrate was shipped in by the Warren Powder Co., candymaking was starting and water analyses were needed.

In 1893 a laboratory accident took Griffin's life and two sulfite pulp mills which comprised most of the firm's consulting business canceled their work. However, new projects made continued operation of the Little Laboratory possible. A partnership with William H. Walker was formed in 1900 and continued until 1905, when Dr. Walker became full professor at M.I.T. To secure greater permanence, the organization was incorporated in Massachusetts, in 1909, with $50,000 preferred stock and $125,000 common. Arthur D. Little became president; Hervey J. Skinner, vice-president; Harry S. Mork, treasurer; and Carl F. Woods, secretary.

Several physical moves were made in these years, first in 1899 to 7 Exchange Place, in Boston's financial district, and in 1902 to 93 Broad St. After incorporation, a tract was purchased in the Fenway district of Boston, but when this district developed along residential lines, attention was shifted to a new location on the Charles River, Cambridge, near M.I.T. The cornerstone of the present main building was laid there on May 8, 1917.

For years Roger B. Griffin and Arthur D. Little were the only qualified experts on the sulfite process in America. They planned and put into operation several mills, among them the S. H. Gray Manufacturing Co. at Newberne, N. C., and the Wisconsin Sulphite Fiber Co. at Monaco, Wis. At one time or another, the Company was sought out by every sulfite pulp mill in the United States and on one occasion was consultant to more than 60 firms.

One early project developed from the analysis of a German surface-coating material, for a Vermont manufacturer, which proved to contain casein. The cost of importing casein being prohibitive, a commercially satisfactory method was worked out for its production by precipitation from skimmed milk. The client shortly thereafter organized the Casein Co. of America, which was soon doing a business of $2,000 per day; the fee for the investigation was $725.

The laboratory initiated research on viscose products soon after Cross, Bevan, and Beadle's discovery in London, in 1893, that cellulose could be solubilized by treatment with carbon bisulfide. In 1899 Little toured Europe to investigate the viscose industry there for a group of Delaware capitalists. In 1900 the Cellulose Products Co., which held options on the American rights to viscose, was formed with Little as chemical director, for laboratory development of viscose products other than fiber, which was already being satisfactorily produced in England. Although the use of viscose in cotton printing, films, and paper coating was successfully worked out, the Company's financial resources were soon exhausted and the options on the process, which could have been had for £11,000, were allowed to lapse. This work led, however, to continued research on production and use of cellulose acetate, which resulted in commercial processes for nonflammable wire insulation, nonflammable motion picture film, and "artificial silk." The patents on film were later acquired by the Eastman Kodak Co., and those on fibers by the Lustron Co., first and for many years sole American manufacturer of acetate silk.

As the Company's scope broadened in the early 1900's, specialists were added to the staff and departments for specialized service organized: Analytical, Research, Coal, Lubrication, Forest Products, Biology, Textile, and Engineering. Gradually the professional status of the staff was raised to a very high level. The gross business increased rapidly, in 1911 being eight times what it had been in 1904.

By Jan. 1918, 16,287 investigations had been made, most of them analytical, and a few over-all process investigations. Among the latter were production of paper from bagasse for the United Fruit Co., the use of bagasse mulch paper to keep down weeds in Hawaiian sugar and pineapple fields, production of alcohol from wood waste, use of Southern long-leaf yellow pine for making kraft paper, and the recovery of turpentine and rosin from pine stumps, leading to design of the Hercules Powder Co. plant at Hattiesburg, Miss.

After World War I, American industry exhibited an increasing interest in research, an interest which Arthur D. Little had done much to encourage during the early years. Many of his talks and essays on the subject were published in 1928 as *The Handwriting on the Wall.* Perhaps his best-known feat in this field was the production of a silken purse from 100 lb. of sows' ears. In 1927 he initiated the *Industrial Bulletin,* a monthly Company publication, devoted to an exposition of current technological developments for the layman. His organization assisted in the formation of many new laboratories, among them the Forest Products Laboratory and the first central laboratory of the General Motors Corp. Little was a member of the Corporation of the Massachusetts Institute of Technology, president of its Alumni Association, and founder of the School of Chemical Engineering Practice; president, American Chemical Society, 1912-13, American Institute of Chemical Engineers, 1919, Society of Chemical Industry, 1928; and Perkin medalist, 1931.

Among the Company's outstanding projects of the 1920's were a survey of the natural resources of Canada for the Canadian Pacific Railway and an investigation of the production of petroleum chemicals. The second led to patents later acquired by one of the present large operators, and to synthesis of the first 100-gallon lot of

isoöctane for the Ethyl Gasoline Corp., for use as an anti-knock test standard. Although this lot cost $25 per gallon, isoöctane later became cheap enough for use as an aviation gasoline component.

From 1922-29 Company research approximately doubled. There was little decline in the first three years of the 1929-33 depression, but a fairly substantial one the next two. In 1935 began a steady growth which has continued at about a constant pace; in 1945 operations were about three times above the 1929 peak. This steady growth in demand for research services was responsible for the final discontinuation of analytical service in 1938.

Little died in 1935 at the age of 72. His will bequeathed his majority stock interest in Arthur D. Little, Inc., to M.I.T., still the controlling stockholder. Earl P. Stevenson, who had joined the Company in 1919 and had served as research director since 1920, succeeded Little as president. During World War II Stevenson was chief of Division 11 of the National Defense Research Committee, concerned with chemical engineering problems. Prominent among its projects were oxygen generation and flame warfare, including the development of the M-69 incendiary bomb, used on Japan. One of the Company's researches in connection with the war effort was the Kleinschmidt compression still, invented at Arthur D. Little, Inc., in 1935. A distillate-fuel ratio three times that possible with conventional equipment made the unit especially attractive for field distillation of water. Units were first designed for submarines and a few were in service at the time of Pearl Harbor. In all, several thousand were made by E. B. Badger & Sons Co. under license from Arthur D. Little, Inc., and by the end of the war, capacity for the daily needs of over 1,000,000 men was in service. Oxygen generation based on new principles led to the development, in cooperation with M.I.T., of the Collins helium cryostat, a relatively simple laboratory device capable of maintaining temperatures down to 2° Kelvin. Other wartime research subjects were flame throwers, incendiary bombs, grenades, protection against attack by flame, laminated plastic body armor, wound-healing ointments, surface coatings, food modifications, and the evaluation of a number of proposed new production processes.

In the past decade Company operations have been extended to such fields as mechanical development and technical-economic evaluation. In recent years there has appeared a growing need for investigation and evaluation of over-all technical-economic aspects of various industrial situations, for clients interested in new areas of industry and for financial interests. This need has been met by organizing a staff of technically trained men especially experienced in this type of investigation.

The officers of Arthur D. Little, Inc., at present are: Earl P. Stevenson, president; Raymond Stevens, Thorne L. Wheeler, and Leroy F. Marek, vice-presidents; Henry G. Powning, treasurer; Frank N. Houghton, secretary; Roger C. Griffin, assistant secretary; Howard J. Billings and Helge Holst, assistant treasurers. The directors include: Marshall B. Dalton, president, Boston Manufacturers Mutual Fire Insurance Co.; Horace S. Ford, treasurer, M.I.T.; Roger C. Griffin; Royal Little, president, Textron, Inc.; Everett Morss, president, Simplex Wire & Cable Co.; Henry G. Powning; Charles E. Spencer, Jr., president, First National Bank of Boston; Raymond Stevens; Earl P. Stevenson; and Alexander Whiteside of Warren, Garfield, Whiteside & Lamson.

LOS ANGELES SOAP COMPANY was "fathered" in 1872 by John A. Forthmann who purchased controlling interest in a small soap works which had been doing business at Second and Spring Sts., Los Angeles, since 1860. A year later, the remaining interest was purchased by his friend, William B. Bergin, and a partnership was formed, known as Forthmann & Bergin. The partners continued

the business at this location until 1874, when they moved to East First St., the present site of the Company. The new factory consisted of a small two-story wooden building, surrounded by orange groves and vineyards. This was two years before the railway reached Los Angeles.

In 1891 William B. Bergin died and was succeeded in the partnership by his nephew, John J. Bergin. This alliance continued harmoniously and successfully until 1897 when the Los Angeles Soap Co. was incorporated. The first directors and officers were: John A. Forthmann, president; John J. Bergin, vice-president and secretary; Horace E. Forthmann, treasurer; Gideon Le Sage; and Isidore B. Dockweiler.

On Aug. 29, 1898, the plant was totally destroyed by fire. Loss was severe, being but partially covered by insurance. Undaunted, the Company immediately set about the building of a larger, better structure on the same site. The new plant when completed was the largest of its kind on the Pacific Coast. Frank H. Merrill had come to the Company in 1897, with a B.S. from M.I.T. and several years' experience in the soap industry. He soon proved himself not only a good chemist but a man of executive and administrative ability, and he was made superintendent of the factory. Today he is president and general manager, a position to which he was elevated after the death of John A. Forthmann.

Up to the First World War the Company manufactured the usual line of household and industrial soaps. However at this time an opportunity presented itself for considerable expansion. There was no soap on the market which worked satisfactorily in the electric washing machine. Merrill, then in charge of manufacturing, worked on this problem and successfully developed an eminently satisfactory soap made very largely of vegetable oils and having the property of increasing efficiency at decreasing temperatures of the wash. This was first marketed under the trade name of White King Washing Machine Soap, but as it was later learned that its use embraced a wider scope, the name was changed to White King Granulated Soap. This was the first granulated soap on the market. To give the housewife what she wanted during the war years, the detergent field was explored, with the result that Merrill produced, through personal development, Merrill's Rich Suds, which is especially popular in hard-water territories.

The other main soaps now manufactured by the Company are: Scotch Granulated Soap, Calla Lilly Granulated Soap, Scotch Triple Action Cleaner, White King Water Softener, Mermaid Washing Powder, Sierra Pine Toilet Soap, White King Toilet Soap, Mission Bell Toilet Soap, and Merrill's Fine Toilet Soap.

The present directors of Los Angeles Soap Co. are: Frank H. Merrill, president; E. Matthew Finehout, vice-president; Jack A. Wood, vice-president, secretary, and treasurer; Annie M. Forthmann; Thomas A. J. Dockweiler; Andrew K. Forthmann; and Victor H. Rossetti.

MAGNETIC PIGMENT COMPANY, now a division of Columbian Carbon Co., originated in the first years of the 20th century. One day in 1903, while Peter Fireman was assisting C. P. Townsend in perfecting his electrolytic process of making caustic soda and chlorine, Elmer A. Sperry, the famous engineer and inventor who was backing the process, showed them a sample of black magnetic ferro-ferric oxide made by A. S. Ramage of Cleveland. Shortly thereafter a printer came to consult Fireman on using a varnish-like petroleum residue for making news ink, if only its color could be changed from brown to black without the use of carbon black. Fireman suggested the iron oxide black and a small order for this was placed with Ramage. The oxide Ramage sent, however, was not black

but brown, and he was unable to produce on a larger scale anything better. Fireman undertook to make a fair and uniform black iron oxide.

E. G. Portner, a former chemistry student of Fireman's at the Columbian, now George Washington University, who for years later assisted him in researches, induced his father, owner of the Portner Brewing Co., Alexandria, Va., to establish a research laboratory for the partnership, "Peter Fireman & E. G. Portner." Progress in making the black pigment was slow, but after many months, about half a pound of fair black was accumulated. A test made by Ault & Wiborg Co. indicated that the pigment was suitable for making printing inks.

Experiments on a larger scale were started early in July, and in Nov. 1904 a process for the production of black ferro-ferric oxide with pronounced magnetic properties was ready. Portner had already bought a half-interest in the enterprise for $4,000. The experiments were followed up with a demonstration and both process and pigment were patented: U. S. Patents 802,928 (1905) and 857,044 (1907).

Confronted with the problem of financing the manufacture and marketing of printing ink, Fireman's partner induced his father to invest $50,000 in the business, the money to be advanced as needed. In a building leased from the Portner Brewing Co., a plant was equipped for the production of magnetic black and another for typographic ink. The most important test of the product was the printing of a full edition of a weekly magazine of many thousand copies.

Greatly encouraged by the result, a saleman was sent out to solicit orders, and in Oct. 1905, a wagonload of ink in 5 and 10-lb. cans left Alexandria and was delivered to printing shops in Washington. The universal complaint of "no gloss" was solved by the addition of carbon black to magnetic black in the ratio 1:1. In the end an ink generally acceptable to the trade and regarded as unique in quality by many users was achieved. The partnership branched into making black lithographic inks, where gloss was not important. The U. S. Geological Survey and the Navy Department found the ink satisfactory for lithographing; the Bureau of Engraving & Printing discovered that magnetic black improved the quality of its engraving ink. Manufacture of colored inks, both printing and lithographic, was begun and the use of black oxide was extended for polishing lenses, mirror plate glass, and the like.

During 1907-8 the partnership struggled to establish itself firmly in the field of printing and lithographic inks. Its Job Black was bought by the Government Printing Office in 1,000 or 2,000-lb. lots; Scribner's adopted Half-Tone Black for its monthly magazine; the Black Rouge business was steadily progressing and the Finkell-Hachmeister Chemical Co. of Pittsburgh became its exclusive distributors in the polishing trade. In the middle of 1909 the Fireman & Portner partenership was dissolved, Portner retaining a royalty on the magnetic black sold and Fireman continuing the business as the Magnetic Pigment Co. The location was moved from Alexandria to Baltimore.

Early in 1911 C. Harold Smith, president of Binney & Smith Co., from which Firemen bought his carbon black, began to show an interest in the black pigment. He bought a half-interest, after Portner was bought out, and the Company was then reorganized and incorporated in New York. Fireman retained the exclusive right to use the "pigment in its various forms in the manufacture of printing and lithographic inks," for which the separate business of the Magnetic Printing Ink Co. was formed. During the next two or three years the Magnetic Pigment Co. was greatly preoccupied with a site for a factory. Norman L. Smith, secretary and treasurer, selected Trenton, N. J., where an arrangement had been made with John A. Roebling's Sons Co., cable works, to use its large quantities of hydro-

chloric and sulfuric acid waste liquors. Regular operations started in July 1914, in a purchased four-story building along a Pennsylvania R.R. track.

After a few months it became evident that there was not a sufficient demand in the entire country for magnetic black to keep the plant going. Possibilities of making iron oxide pigments of various colors were explored. The Company started to make reds and yellows about the same time. The new reds, made from precipitated ferro-ferric oxides, had nothing in common with iron oxide reds which had been known for centuries and were produced by roasting copperas. They were an immediate success and in about a year were on the market and well established. The yellows approached standardization in Mar. 1915. Only in 1918 was a degree of uniformity attained in the production of browns. During the first three or four years of operation in Trenton, a crimson, a purple, and a tan brown were also brought out. It was not however until 1919 that Magnetic Pigment found its level in the pigment trade as to colors and prices. Meanwhile the Magnetic Pigment Printing Ink Co. had moved to N. Y. City, but had to vacate a couple of years later. It resettled in Trenton and was eventually given up.

During 1919-22 the progress and growth of the Magnetic Pigment Co. were steady. Its Brown 2574 was found to be highly suitable for rotogravure printing, then just coming into great vogue. In 1922 the Company purchased outright the National Ferrite Co., Farmingdale, L. I., which manufactured an iron oxide yellow invented by Russell S. Penniman and Norman M. Zoph of Berkeley, Calif. (U. S. Patents 1,327,061 and 1,368,748). At the time Zoph had separated from National Ferrite and organized the Synthetic Iron Color Co., of Richmond, Calif., with the right to exploit the so-called Ferrite process in California and all other states west of the Rocky Mountains. National Ferrite retained rights in all the other states. Magnetic Pigment Co. kept the Farmingdale plant running until it was ready to operate the Ferrite yellow process in a specially built plant in Trenton, July 1923.

From the time Magnetic Pigment Co. came to Trenton, C. Harold Smith stood ready to lend the Company enough money to keep it well equipped for the growing business. On the board of directors were Peter Fireman, president; Reid L. Carr, vice-president; Norman L. Smith, secretary-treasurer. But C. Harold Smith sat in at all meetings. In 1927 C. Harold Smith suggested selling out to the Columbian Carbon Co., New York, of which he was a large stockholder. The exchange of stock took place early in Jan. 1929. Adolph Harvitt, chemical engineer with Magnetic Pigment since 1926, became manager of the Trenton plant, while Fireman continued in an advisory capacity.

Nothwithstanding the considerable number of reds made by the Magnetic Pigment Co., not a single one was acceptable to the rubber manufacturers. Fireman undertook an experimental study of the old subject of calcining copperas and was successful in developing a new red entirely satisfactory for use in rubber. The Columbian Carbon Co. authorized the Magnetic Pigment Division to build a plant for the manufacture of "rubber red," near Monmouth Junction, N. J. In laying out the plant, Fireman was assisted by Morris Isserlis. In the fall of 1936 manufacturing operations started, using a joint continuous process for drying and calcining (U. S. Patent 2,184,738).

From the time of its assignment to the Columbian Carbon Co., the Magnetic Pigment Division has steadily grown and its production of 17 shades of iron oxides has been greatly increased. Plans are now well under way for a new addition and a large new copperas calcining plant is almost completed.

While the paint trade takes the largest share of iron oxide pigments, the ceramic, rubber, textile, paper, floor covering, and glass industries are also large-scale customers. During World War II, almost the entire Ferrite yellow output was

allocated for war use, the plant receiving two Army-Navy "E" awards for excellence in quantity and quality of production.

Sales and distribution of Mapico colors are made by Binney & Smith Co., with branch offices and agents throughout the United States and many foreign countries.

MAGNUS, MABEE & REYNARD, INC., has a story parallel to, and a miniature of, the tremendous growth of America since the year 1895—a 53-year period that saw this country's emergence as an industrial giant and the most completely self-sufficient nation on earth. At the turn of the century the greatest boast of this firm was the pre-eminence of the foreign houses whose agencies it held. America then had little time for the production of such niceties as dyestuffs or imitation flavors. At the founding of MM&R the greatest bulk of the essential oils was imported; now, after half a century, most of its essential oils and all its compounded materials are American. And instead of holding agencies of foreign firms, MM&R has its own foreign representatives throughout the world. But MM&R's rise was not entirely an automatic process brought about by the rise of America. The firm took full part in the country's struggles; grew in spite of depressions and setbacks; and now stands possibly the largest house of its kind in the country.

MM&R began when Percy C. Magnus, born at Rome, Ga., in 1861, as a lad entered the employ of a physician who, as was then customary, dispensed most of his own remedies. Armed with this experience, he went to Atlanta and became a drug clerk and a few years later a partner in one of the first chain of drugstores in the United States, known as Magnus & Hightower. The firm was sold to other interests and Magnus, after several years' traveling for a wholesale drug firm in the South, and after nearly joining the Crown Perfumery Co. of London, was offerred in 1895 the position of sales manager of McKenzie Bros. & Hill. Recently created with offices at 52 Water St., N. Y. City, and factory at Watsessing, N. J., this firm dealt in essential oils, flavors, and basic perfume materials of which the bulk was imported. It also manufactured various aromatic chemicals mostly based on camphor oils and including heliotropin crystals as a leading specialty. The firm boasted the agency for E. Sachsse & Co. of Leipzig, one of the great essential oil firms of Europe.

In Dec. 1897 the two McKenzie brothers withdrew from the firm and the Frank Hill Co. was created with Frank Hill and Percy C. Magnus as officers. This title and corporate structure continued through 1898 until Hill's death. In Dec. 1898 the company was reincorporated as Magnus & Lauer, with Magnus, president, and Monroe W. Lauer, vice-president and treasurer. The authorized capital was $40,000. Additional agencies were accepted from European suppliers and the line enlarged to include vanilla beans, also vanillin and coumarin, at that time comparatively new aromatic chemicals.

The business grew rapidly. In 1901 the company maintained sales offices in Philadelphia, San Francisco, Kansas City, Chicago, St. Louis, and Pittsburgh. In 1905 it held the agencies of Hugues Aine of France; Société des Huiles d'Olive de Nice of France; McKenzie Bros. of Japan; Spurway & Co. of France; and George E. Pierce, Italy. That year Lauer died and the expanding business moved to larger quarters at 257 Pearl St., N. Y. City.

The name of Magnus, Mabee & Reynard, Inc., made its appearance in 1907 when Magnus & Lauer merged with the National Essential Oils Distilling Co. of Chester, Conn. Percy C. Magnus was president; D. W. Mabee, vice-president; G. C. Reynard, secretary, and D. W. Mabee, Jr., treasurer. The Company began to distribute its products by wholesale druggists and sell extensively to pharmaceutical and candy manufacturers, bakery and confectionery supply houses, household

remedies and extract manufacturers, and some 30-40 other trades. It claimed "the largest single distillery in the United States, at Chester, where we distill such articles as extract witch hazel, oils of allspice, birch, cubebs, cloves, sandalwood, etc." Late in 1910 Percy Magnus purchased 95% of the firm's stock, the remaining few shares being held by some of the older, active employees and officers of the Corporation.

World War I, cutting off important sources of supply, presented some great problems for the Company. Shortly before the United States entered the war, Percy C. Magnus, Sr., died. Percy C. Magnus, Jr., succeeded his father as president; Joseph B. Magnus, the second son, was elected treasurer. During the war the firm filled many contracts for the U. S. Army and Navy, as well as most of the Allied governments. In 1917 MM&R made its first drive for export trade, its catalog advising that "We are especially well-equipped to handle export orders for chemicals, essential oils, vanilla beans, lime juice, etc. . . . if not convenient to correspond in the English language, use your own and we will reply in the same." It succeeded in making considerable inroads on European competitors and today is a leading export house. In 1922 Robert B. Magnus, youngest son of the founder, became treasurer and Joseph B. Magnus was made vice-president.

The 1920's and 1930's were years of steady, almost phenomenal growth, marked by a gradual discontinuation of foreign agencies as the aromatic chemical industry of the United States and the Company's own manufacturing facilities were increased. The demands for more space increased until the firm in 1938 removed to greatly enlarged, more modern facilities in a new building at 16 Desbrosses St., a six-story plant said to have been the first industrial glass-brick building in N. Y. City. In 1942 a smaller adjoining building was made an annex; and in 1947 a six-story building at 15 Vestry St. was purchased, making a total floor space of over 250,000 sq. ft. It is amusing to compare this with MM&R's boast in its 1914 catalog: "We have the largest essential oil house in the United States . . . with a total floor space of 16,104 sq. ft."

MM&R's pre-eminence is due not only to the leadership of its president, Percy C. Magnus, and its two executive vice-presidents, Joseph B. Magnus and Robert B. Magnus, but also to the long experience and service of its other officers: William F. Fischer, who joined the firm as office boy in 1907 and has been sales manager since 1927. George H. McGlynn became associated with the Company in 1920 as purchasing agent, later assumed charge of the Export Department, and is today treasurer. In 1921 Arthur H. Downey entered as an assistant in the analytical laboratory and now is technical director. Fernand G. Robin, formerly representative for Mexico, became export manager in 1934 and on his death in early 1948 was succeeded by Dr. Henri F. Logcher. In addition, the following are key men: G. F. Mehren, Midwestern sales manager, Chicago branch; T. B. Berentsen, director of procurement; Milton Stern and Frederick Loeser, assistants to the sales manager; M. S. Barker, J. W. Felton, Jr., and S. C. Gamage, district sales managers; D. Bellavigna, production superintendent; and Bert Hayes, plant superintendent. The firm is represented in Los Angeles by the Braun Corp.; in San Francisco by the Braun-Knecht-Heimann Co.; in Washington and Oregon by Van Waters & Rogers, Inc.; and in many foreign countries by various native agencies as well as its own representatives.

MALLINCKRODT CHEMICAL WORKS is a monument to the vision of three brothers, Edward, Gustavus, and Otto, who in the fall of 1867 founded G. Mallinckrodt & Co., to engage in the production of fine chemicals, particularly for medicinal use.

These three young men, members of a pioneer Missouri family, had long hoped to embark on a manufacturing venture of their own and toward this end each developed his individual talents through study and practical experience. Gustavus spent several years with the Richardson Drug Co., one of the oldest wholesale drug houses in the Middle West, and became a divisional manager. Because of his experience, Gustavus assumed the administration and general management of the Company which was named after him. He recognized Edward's great aptitude for chemistry and convinced their father of the value of a college education. Edward spoke up for Otto and upon the two younger brothers fell the responsibility for the technical aspects of the business.

At that time the entire Midwestern region was but sparsely settled and there wasn't a wholesale druggist between St. Louis and California. Europe was the center of the world's chemical industry and with but few exceptions medicinal and other fine chemicals were imported. If G. Mallinckrodt & Co. was to prosper it must obtain a fair share of business from the East, in direct competition with well-established fine-chemical companies. Twice the new business came perilously close to failure. Adherence to a high standard of business practice and the rapid growth of the Middle West after the Civil War assured its survival.

The first plant, a one-story stone structure with three wooden sheds and a stone "acid house" attached, was erected under Edward's supervision. The original manufacturing processes consisted largely of purification of commercial-grade chemicals and the preparation of a few simple organic compounds.

Mallinckrodt was one of the first and for many years the largest manufacturers of bromides in the United States, importing the bromine from Stassfurt, Germany. In 1873 two distilling plants were set up on the Ohio River to recover bromine from the brines of salt wells. The manufacture of iodides was also begun during this period and to this day Mallinckrodt is one of the most important producers. The introduction of burnt alum for the baking powder trade in 1875 was the Company's first large-scale venture into industrial fine chemicals.

With the untimely death of two brothers in 1876, the entire responsibility for the business fell upon Edward Mallinckrodt, who incorporated it in 1882 as the Mallinckrodt Chemical Works. In 1883, while portable cameras were still a novelty and two years before the development of the roll film, Mallinckrodt began manufacturing photographic chemicals. Next year a sales office and warehouse were opened in New York to supply the increasing demands for Mallinckrodt chemicals in the East and three years later a factory was established at Bergen, N. J.

During the nineties several important products were added to the Mallinckrodt line: hydrogen peroxide, the narcotics, and the nutgall products, gallic and tannic acids. By the turn of the century the list totaled over 500 and the staff of four men who manned the original plant had grown to more than 400.

The decade from 1900-1910 witnessed further growth in the St. Louis and Bergen plants, and the establishment of a sales office and warehouse in Philadelphia in 1904. During this period Mallinckrodt, long an important manufacturer of ether, pioneered in the development of the highest possible grade of anesthetic ether. It improved containers, packaging methods, and researched the effect of small amounts of impurities. This research is still being carried on today. In 1908 the manufacture of zinc stearate was started at St. Louis, a forerunner of the complete line of stearates since developed.

In 1913 Mallinckrodt established the Montreal office of the Mallinckrodt Chemical Works, Ltd. Also this year, barium sulfate for X-ray diagnosis was produced. During the World War I boom, Mallinckrodt adopted the realistic policy of long-

range planning which insured the permanency and soundness of the changes which were made to meet the greatly increased demand upon the Works.

The Chicago sales office was established in 1920. Although manufacturing chemicals of a purity suitable for reagent use for many years, it was not until 1922 that the Company established the analytical reagent line. In 1923 stearates other than zinc were added, among them aluminum stearate, which had been prepared experimentally by Mallinckrodt 20 years earlier.

A long and able career was terminated with the death of Edward Mallinckrodt, Sr., in 1928. He was succeeded as board chairman by his son, Edward, Jr., who had joined the Company in 1901 after his graduation from Harvard.

The thirties for Mallinckrodt was a period of considerable expansion and progress. In 1930 a manufacturing plant was established at Toronto, which had to be moved in 1938 to a larger site in Montreal. A new laboratory building was erected at St. Louis in 1936. Additional sales offices were established in Cleveland, Los Angeles, and San Francisco. Cyclopropane, mandelic acid, and other new products were added to the line.

During World War II, Mallinckrodt's facilities for medicinal products were strained to the limit. Production of ether, narcotics, bromides, iodides, mercurials, tannic acid, barium sulfate, Iodeikon, and iron salts was greatly increased. The Army Medical Depot in St. Louis frequently drew upon the Company's knowledge and experience in problems of materials specifications and methods of packaging.

Aluminum, calcium, and zinc stearate soaps contributed to the lubrication of war machines, to waterproofing of military equipment, and to the production of synthetic rubber. Pyridylmercuric salts were used as antimildew agents for tent cloth. Mallinckrodt precision manufacturing techniques helped in the development of black camouflage paint and perfection of one photographic method of making glass scales and gratings for military optical instruments. High-purity mercuric oxide went into the miniature electric batteries and potassium sulfate was manufactured for the Ordnance Department as a gun-flash depressant. Foremost was Mallinckrodt's production of uranium oxide, which the Smyth Report describes in the following words: "This oxide is now used as a starting point for all metal production, and no higher degree of purity can be expected on a commercial scale. In fact, it was a remarkable achievement to have developed and put into production on a scale of the order of one ton per day a process for transforming grossly impure commercial oxide to oxide of a degree of purity seldom achieved even on a laboratory scale."

Today, Mallinckrodt is a far-flung business with more than 100 factory and office buildings located in nine cities in the United States and Canada. The staff comprises over 1,500 employees; the price list embraces more than 2,000 items. One of America's oldest chemical manufacturers, Mallinckrodt marked its 80th anniversary in 1947.

MARATHON CORPORATION'S founders were a group of lumber men whose principal objectives were to secure better utilization of timber resources and to develop water-power rights which they held on the Wisconsin River. They organized the Marathon Paper Mills Co. in Wausau, Wis., in Feb. 1909, with $750,000 capital. The first officers were Cyrus C. Yawkey, president; Charles J. Winton, vice-president; Benjamin F. Wilson, secretary; Walter Alexander, treasurer. These men with Neal Brown, counsel, Walter H. Bissell, and Granville D. Jones comprised the first board of directors.

Since the promoters of the Company were unacquainted with the pulp and paper industry, they engaged David C. Everest, a young man active in the business

for some time, to construct and operate the first mill. Since that time in continuous charge as vice-president and general manager, and later as president, Everest, by his keen foresight, sound judgment, and unusual ability to handle men has been largely responsible for Marathon's growth and success.

The power dam for the mill was started at Rothschild, Wis., in May 1909. The sulfite pulp mill and the paper mill were completed in quick time and the first paper came off the machines in Nov. 1910. Within two years the Company experienced two disastrous floods which cost over $1,000,00 but which did not close down the plants.

Anticipating trends of the industry, Everest had installed cylinder, Fourdrinier, and Yankee paper machines, together with plants to produce both sulfite and groundwood pulp. The Rothschild mill had one of the first pulp-bleaching plants and so was in an unusually good position to supply high-grade papers. In 1916 this led to a connection with the Menasha Carton Co., founded a few years previously by George H. Gaylord, which was manufacturing butter cartons, bread wrappers, and other food-packaging materials requiring high-quality pulp and paper products. Menasha became such a substantial customer that Marathon's capital stock was increased to $5,000,000 in 1927 and Menasha taken over entirely, thus adding plants at Menasha, Wausau, and Ashland, Wis.

Then followed a period during which the Company expanded its markets in food-packaging materials and developed new types of sheet materials. Because the supply of pulpwood was diminishing rapidly in the Middle West, Everest studied the Canadian situation, assigning Perry M. Wilson, secretary-treasurer of the Company, the responsibility for locating suitable timber tracts. In 1937 and 1944, long-term leases were concluded with the Canadian Government, whereby Marathon had timber-cutting rights on approximately 4,000 square miles of land.

In 1944 the Company changed its name to Marathon Corp. and the preferred stock was increased to 50,000 shares of $100 par value. Another paper mill was acquired at Menominee, Mich., that year. A 300-ton sulfate pulp mill started at Marathon, Ont., on the northern shore of Lake Superior began pulp production in Nov. 1946. The cost of this mill and townsite, coupled with a desire to eliminate funded debt, brought about a refinancing program in 1946. As a result, the Company has outstanding today 50,000 shares of $100 preferred stock and 1,300,000 shares of common at $6.25 par.

Marathon Corp. now has three operating divisions, each headed by a vice-president: Canadian Pulp Division, John Stevens, Jr.; U. S. Pulp & Paper, Leo E. Croy; and Chemical Division, Allen Abrams. The board of directors comprises these four men and Judd S. Alexander, Lester Armour, L. Frank V. Drake, Charles S. Gilbert, Matthew P. McCullough, Charles J. Winton, Jr., and Aytch P. Woodson. In the Chemical Division, J. Richter Salvesen is director of research and F. M. Truesdale, director of sales.

Everest was one of the early pulp and paper manufacturers to recognize the practical value of organized fact-finding. Today he is the only nontechnical man to have received the medal of the Technical Association of the Pulp & Paper Industry. In 1926 Marathon expanded research under Allen Abrams, who had considerable experience in the pulp and paper industry. From that time, the Company has continued to expand its technical program, until it now has a large, modern research building.

In 1927 Guy C. Howard approached the Company with a process for reclaiming lignin materials from sulfite waste liquor, long a nuisance to the industry. Early attempts had been made to utilize or dispose of over 1,000,000 tons of lignin lost in U. S. each year, generally by evaporation of the whole liquor. Instead of

evaporation, Howard treated the liquor with lime to remove the inorganic constituent as calcium sulfite; then, with more lime, to precipitate the lignin as calcium lignosulfonate. The original intent was to return the calcium sulfite to the pulp-cooking system and to burn the lignin as fuel.

The first recovery plant was installed at Rothschild in 1935. Research conducted by Howard, J. Richter Salvesen, and Lloyd T. Sandborn showed the possibility of making vanillin from lignin. In 1937 a plant was erected at Rothschild and the Salvo Chemical Corp., a subsidiary of Sterling Drug Co., began manufacturing vanillin in such quantity that it constitutes nearly one-half the domestic production. Further research indicates other fine chemicals may be produced by cracking lignin through high-pressure cooking, but present uses are principally in the form of lignin salts. Calcium lignosulfonate is employed as a grinding aid in Portland cement and binder for foundry cores; calcium and magnesium lignosulfonates are used for tans; sodium lignosulfonate makes an excellent dispersant and boiler compound. Marathon is recovering about 15,000 tons of calcium lignosulfonate annually.

MARINE MAGNESIUM PRODUCTS CORPORATION was organized by Robert E. Clarke in June 1927 as the Marine Chemicals Co., Ltd., six months after a license under U. S. Patent 1,505,202 was negotiated covering a process for the recovery of magnesium salts from sea water by the use of clarified lime water. The patent was issued to Edward K. Judd, at that time an associate professor of chemistry at Columbia University and one of its co-owners, Alfred M. Thomsen, claimed the process had been perfected through experimental work performed at Port Monmouth, N. J., and was ready for commercial operation.

Clarke felt that if the process could be demonstrated to be practical and a fairly pure grade of magnesium hydroxide produced for the cost indicated, it would ultimately become a cheap raw material for metallic magnesium and its salts. He was able to visualize such a result based upon six years' association with D. C. Jackling, originator of a process for recovering copper from ore containing less than 1%. His forecasting proved correct as there are now six large plants producing magnesium hydroxide from sea water in this country and England, which material is processed into magnesium metal and magnesium oxide for refractory and other purposes. It was one of the principal raw materials of the metal during World War II.

A small plant at South San Francisco, which had been erected in 1918 to produce a wartime chemical, together with about $5,000 in cash was made available to Thomsen, who agreed to superintend the commercial development of the process. After six months, when $10,000 had been spent with no tangible results, Thomsen left to devote himself to other interests. It was then decided the process had not been sufficiently developed even for a small-scale pilot-plant operation, so all operations were suspended except for laboratory work conducted by Clarke and an assistant.

When Marine Chemicals was organized with 10,000 shares common no-par value, no attempt was made to sell stock until the process was further perfected, except to cover the original investment of $13,000. In 1928 the capitalization of the Company was changed to 1,000 shares 8% cumulative preferred $100 par value and 10,000 shares common no-par value, and $81,500 worth of stock was sold.

In 1929 the capitalization was changed to 10,000 shares A common and 30,000 B common no-par value, the preferred being exchanged for the A stock on the basis of four shares for one and additional A stock was sold in 1929-31 for $74,-000. Between 1934-36 there were issued 4,700 shares of common stock to cover

interest and principal of notes of $47,000. In 1939 capitalization was again changed to 150,000 shares of common of $1 par value, the old stock being exchanged four for one and 14,260 shares sold at $6 per share or $85,560. At present there are 100,000 shares outstanding representing a cash investment of $300,000.

Sufficient laboratory progress had been made by 1928 to justify installing of equipment to demonstrate the process on a pilot-plant scale of about 1,000 lb. of magnesium carbonate daily. By the end of 1929 this capacity had been doubled with a total investment of approximately $125,000. In Jan. 1930 the capacity of the plant was increased to approximately three tons daily. It was difficult to raise funds for this expansion on account of the debacle in the stock market in 1929. However, equipment suppliers gave generous terms of payment which permitted the financing of the additional machinery required.

So many technical and chemical difficulties were encountered with the Judd process that it was abandoned. The principal trouble lay in the inability to clarify large quantities of lime water. A five-ton daily magnesium carbonate plant requires approximately 300,000 gal. sea water and 1,000,000 gal. clarified lime water. A satisfactory precipitation process, using milk of lime, was developed and patented. In 1932 a unique washing process of purifying the precipitated magnesium hydroxide was developed and is still in use. It is covered by U. S. Patent 2,019,488, Nov. 5, 1935.

In 1931 the Morton Salt Co., Marine's principal customer, purchased the Ruggles & Rademaker Salt Co. at Manistee, Mich. As this company was producing bromine salts in addition to sodium chloride, Morton Salt decided to recover also the magnesium salts from the brine, provided a suitable process could be developed. Marine Chemicals undertook to develop such a process under the direction of Dr. Paul D. V. Manning. This research was successful, resulting in a process covered by U. S. Patent 2,041,047, May 19, 1936. A plant was erected by the Morton Salt Co. at Manistee, which came into production in 1933.

At South San Francisco the plant has been gradually enlarged until it occupies seven acres and has a daily capacity of approximately 75,000 lb. of different magnesium salts. The location is on San Francisco Bay at Point San Bruno, San Mateo County, and has excellent rail and highway connections. The Company has confined itself to the production of high-grade magnesium carbonates, oxides, and hydroxides, although some research has been devoted to the metal. It has also developed cheap processes for the recovery of 99½% magnesium salts from dolomite rock and other magnesia-bearing rocks and brines. The Company owns 24 domestic patents covering its process and products, and has a number of patent applications pending. Many of these processes are covered by foreign patents.

With an investment of over $1,000,000 since its organization, the Company operated at a loss of approximately $9,000 from 1928-36, but from 1936-45 has earned $722,000 in operating profits. Its sales have increased from $5,400 in 1928 to $570,000 in 1945. All marketing of products is done through chemical distributors.

A definite research program was adopted in 1940. There was no research budget, but during a six-year period approximately $250,000 has been spent. The principal development during this period was a new process for the recovery of magnesium oxide from magnesia-bearing ores and brines.

All the activities of the Company, including technical, production, marketing, financial, and research are under president Robert E. Clarke, the principal stockholder. The technical personnel has included William H. Farnsworth, 1927-32, Dr. Paul D. V. Manning, 1931-32, Dr. Henry H. Chensy, 1932-36, Dr. Gunter H.

Gloss, 1940-46, and Neil R. Collins, who rose from operator and chemist to general sales manager, and Clarke's right-hand man.

MASONITE CORPORATION is a result of the inventive genius of William H. Mason, from whom the corporate name was derived. Mason was born in 1877, studied engineering at Washington and Lee and Cornell Universities, and after serving in the Spanish-American War, worked closely with Thomas Edison in connection with the development and manufacture of phenol, Portland cement, and other products. After 17 years with Edison, Mason left to construct shipyards at the outbreak of World War I.

From 1920-24 Mason, with a young assistant, C. H. Westphalen, worked for the Wausau-Southern Lumber Co. at Laurel, Miss., on methods of extracting naval stores from pine lumber. Meanwhile, appalled at the great amount of wood waste sent to the trash burners, he was striving to find some way of converting this waste to wood fibers and thence into a salable product.

Knowing that wood fibers are held together by lignin, Mason reasoned that by subjecting the wood to heat, moisture, and pressure it might be possible to soften the lignins and blow the fibers apart with the same steam that had been used to soften the wood. His first steam gun was a piece of old shafting some three inches in diameter and about 15 inches long, from which fiber was exploded at approximately 600 lb. pressure. The principle of steam explosion demonstrated, experiments were continued to establish the best working pressures and proper temperatures and times. The next step was to find the best product to be made from the new raw material. Two were the immediate outgrowth of Mason's process—insulation board which entered a field already well established, and a hardboard soon to become known the world over as Presdwood.

The experimental data were laid before a group of lumber and paper mill men, known as the Wausau group, and the Mason Fibre Co. was organized in Sept. 1925 to construct a plant, with Charles Green, president; W. H. Mason, vice-president and general manager; J. A. Weiner, superintendent; C. H. Westphalen, laboratory; and E. J. Schneider, chief engineer. The venture was financed by men whose chief interest was in the possible utilization of a waste product of the lumber industry. The plant was completed in June 1926 and operations began in September. Raw material came from the adjoining Wausau-Southern Lumber Co.'s mill. The process used today is essentially the same except for some changes and improvements.

In order to operate the growing plant more effectively the Company was reorganized in 1928 as the Masonite Corp., with S. B. Bissell, president; W. H. Mason, vice-president, research and development; J. H. Thickens, manager; C. H. Westphalen, superintendent; E. J. Schneider, chief engineer. By Apr. 1931 the output was 500% over the 1926 production. Employees numbered 450, in addition to a large sales force.

The next few years brought about several changes which made it necessary for Masonite to use more and more round wood in the process. First, due to the great increase in production of Masonite products, the sawmill waste supply became insufficient to meet the chip requirements. Second, this period saw the virtual exhaustion of virgin timber in the state and the consequent emigration of the major lumber companies. Third, better hardboards could be made from chips free from bark. Eventually this round wood, obtained from second-growth trees, was used exclusively. The Corporation embarked early upon a timberland acquisition program, and at the present time owns more than 170,000 acres on which it cuts wood in the same manner as it recommends to other suppliers. It also

gives 1-2,000,000 pine seedlings per year to farmers and individual landowners in order to replace, in a measure, the material it cuts.

In 1929 a Research Department was organized by Mason, who was vice-president in charge of research and development until his death in 1940, with Robert M. Boehm, director. Starting with a staff of four and a minimum of equipment, the Department today has a completely modern laboratory and a staff of more than 50.

In the early 1930's a research project was started on lignocellulose. In the manufacture of paper and cellulose products, lignin is the unwanted by-product and is customarily removed. In the Masonite process, however, it is utilized as the binding agent. On studying the bond secured between lignin and wood in Presdwood, it was discovered that at one stage part of the wood is converted to a resinous material by depolymerization of the lignin fraction. This led to a long study of the effects of high-temperature hydrolysis of wood. It was finally found that by carefully controlling the moisture in the wood and the temperature and time of heat treatment, the wood could be converted to a predominantly plastic state which, when the water-soluble end-products were removed, could be molded to a homogeneous plastic. This product is noncompressible, has high water resistance and desirable electrical properties. It is low-cost and may be turned, punched, tapped, sawed, or drilled. In 1935 a large separate plant was erected for its manufacture, but extensive research is still being done on the product.

In 1930 a chromium-plating plant was built for the purpose of coating steel press plates. The chromium-plating baths are among the largest in the world. In 1936 a method was worked out whereby a smooth top surface could be given to insulation. S2S Presdwood, a board with density higher than Presdwood, was put into production in 1938. In 1939 a modification of the S2S process was used to make Die Stock, a hardboard of considerable density used in the aircraft industry during World War II.

The "shooting" of wood chips in the Masonite gun is in reality a high-temperature acid hydrolysis of the woody material, consisting essentially of extractives (small amounts) lignin, cellulose, and hemicellulose. The hydrolysis converts the sugars in hemicellulose into water-soluble hexosans and pentosans, which, together with a small amount of solubilized lignin, give fractions that can be concentrated to liquor and subsequently dried to a powder. Two hemicellulose extracts now being marketed as Masonex (liquid) and Masonoid (powdered) are suitable as binders or as nonedible substitutes for dextrin. Their value as raw material for organic chemicals is being investigated. Wood fibers too fine for Presdwood go into Benaloid "1000," a finely divided lignocellulose wood flour, which is compatible with phenolic, furan, urea, thiourea, melamine, and most thermoplastic resins.

In 1939 Masonite purchased from Johnson & Johnson a plant in Chicago for making a light-weight insulation board called Cellufoam. Soon after its inception, Masonite began installing its process in distant parts of the world. It has built or supervised plants in Sweden, Italy, Australia, and Quebec. The latest one will be in South Africa.

At the present time Masonite's pay roll exceeds 3,000 individuals and production runs well into the hundreds-of-millions of square feet of hardboard products annually, totaling as high as $18,763,938 in net sales per year. Current officials are Eugene Holland, president; C. H. Westphalen, John M. Coates, W. G. Stromquist, and D. C. Everest, vice-presidents.

MATHIESON CHEMICAL CORPORATION is typical of the industrial development of this country. Established as the Mathieson Alkali Works in 1892, with an initial capital of $1,710,000, it has grown in 56 years to a company with gross assets, before property depreciation, of over $60,000,000, production of over 600,000 tons of basic chemicals annually, ample resources of raw materials, and plants at Niagara Falls, N. Y., Lake Charles, La., and Saltville, Va. Started to manufacture caustic soda and soda ash, the Company continues to be primarily a producer of heavy chemicals, adding later bicarbonate of soda, chlorine, ammonia, and dry ice. In recent years activities have been diversified through the production of related chemical specialties including calcium hypochlorite products, fused alkali products, sodium chlorite products, and sodium methylate.

The idea of a new alkali company originated about 1890 with a group of American businessmen, W. F. and F. C. Sayles of Saylesville, R. I., Edward E. Arnold of Providence, G. W. and C. F. Palmer of Saltville, Va., and the R. T. Wilsons, father and son, of New York. The site selected was Saltville, Va., where both salt and limestone were available in quantity, as well as coal from the near-by fields of Virginia and West Virginia. To supervise construction, the services of Thomas T. Mathieson, son of Neil Mathieson of England, were obtained. Neil Mathieson had long been a prominent manufacturer supplying alkalies to the American market. The Mathiesons had recently disposed of their factory in England and they and their workmen and technical men could provide invaluable construction and operating experience.

Since the new enterprise proposed to manufacture products on a par with those of the Neil Mathieson Co., it was decided to acquire the right to use the Mathieson name. The officers for the first year were Edward E. Arnold, president; George W. Palmer, 1st vice-president; R. T. Wilson, Jr., 2d vice-president; Charles H. Bosher, New York, treasurer; and M. P. Robertson, Brooklyn, N. Y., secretary. Directors were E. E. and W. O. Arnold, W. F. and F. C. Sayles, Moses Newton, R. T. Wilson and R. T. Wilson, Jr., and G. W. and C. F. Palmer. Chartered in Virginia, Aug. 13, 1892, the Company purchased salt properties at Saltville. These great deposits in the extreme southwestern corner of Virginia had been known since earliest times and were the chief salt supply of the Confederacy during the Civil War. In 1893 Thomas T. Mathieson acquired Holston Salt & Plaster Co.'s entire salt works and 12,000 acres. Construction proceeded during the next two and one-half years under his supervision. On July 4, 1895, the first product was manufactured at Saltville, and shortly thereafter Mathieson returned to England. Soon after operations started, the design and construction of the plant, being based on the English method of manufacture, were found inadequate to compete successfully with other American manufacturers. All the operations were carried out by hand, and the products, although satisfactory in quality, were produced at excessive costs. It was therefore necessary to convert to mechanical handling.

During 1894 arrangements were made with Hamilton Y. Castner for the control in this country of his electrolytic cell for the production of caustic soda and chlorine. Using this cell, a single-unit plant was first constructed at Saltville and put in operation during the winter of 1896. It was here that bleaching powder was first manufactured on a commercial scale in the United States. The Castner unit demonstrated the feasibility of the process, but low-cost power was needed for commercial success. It was therefore dismantled and a new and larger unit installed at Niagara Falls, N. Y., which began operations on Thanksgiving Day, 1897. This new unit operated as the Castner Electrolytic Alkali Co. until 1917,

when it was merged with the parent company under the name, the Mathieson Alkali Works (Inc.).

In the early days the chlorine from the electrolytic cells was absorbed in lime and shipped to consumers as bleaching powder. It had long been known that chlorine gas could be liquefied under proper conditions, but suitable compressing equipment was lacking, as well as satisfactory containers for transporting the liquefied product. Work on the problem was begun in 1908 and the first commercial production of liquid chlorine was started by Mathieson, Apr. 5, 1909. In 1910, realizing that larger containers than cylinders would be required for shipping liquid chlorine, Mathieson engineers built the first one-ton container. During and just after World War I, large numbers of these containers were placed in service. Increased demand for chlorine at this time also led to the shipment of liquid chlorine in tankcars of 15 tons each. Mathieson engineers, believing the ton-container to be a better unit for some types of consumers, designed and placed in service the multi-unit tankcar carrying 15 one-ton containers. Another shipping problem was the design of a satisfactory cylinder valve. Experiments led to the development of a specially-designed Mathieson valve, later adopted as standard by the Chlorine Institute.

About 1917 experimental work had been started at Niagara Falls on the fixation of atmospheric nitrogen as cyanide. Further work led to the production of synthetic ammonia for a short time in 1919 and again on a small scale in 1922. The latter process having proved successful, a new plant was built and the first unit put in operation in 1923. The new process combined by-product hydrogen from the electrolytic cells with atmospheric nitrogen to make pure ammonia. Cost of production was considerably lower than ammonia obtained from ammoniacal liquor, so that other producers were quick to fall in line, both as to selling prices and method of production.

Until the early 1920's caustic soda had been distributed, even to the largest consumers, in solid form in drums. In 1922 Mathieson started distributing liquid caustic soda in tankcars by shipping its electrolytic cell liquor, containing about 25% caustic, to certain consumers within an easy radius of the Niagara Falls plant. Later, more concentrated solutions were shipped until the present standard concentrations of 50% and 73% were reached. In 1923 manufacture of fused alkalies in briquette form started in Saltville. This group of specialities now includes Purite, a fused soda ash used in refining and desulfurizing iron and nonferrous metals; PH-Plus, fused alkali briquettes for water softening and pH control; Super Mafos, slow-dissolving briquettes and tablets for use in dishwashing machines; and Super Nufos, briquette cleanser for use in dairy plants. Another development at Saltville is dry ice, started in 1931, and the distribution of carbonic gas (liquid carbon dioxide), started in 1937. As the market for these products has expanded, the capacity of the plant has increased until, with completion of the expansion program early in 1948, it has become one of the largest producers of dry ice in the world. Mathieson distribution of carbon dioxide products now extends from New York to New Orleans through 16 Company-owned-and-operated warehouses.

In the early thirties Mathieson, having made a survey of the Gulf Coast region, decided upon Lake Charles, as a favorable site for a new alkali plant. Here salt was available in ample quantities, lime could be obtained from oyster shells, and fuel in the form of natural gas was available from near-by fields. The location was also favorable for transportation by rail and water. Construction started and the new plant was completed the day after Christmas, 1934—one year later. Regular shipments of caustic soda and soda ash began moving Feb. 1, 1935.

At Lake Charles also, shortly before the start of World War II in 1939, Mathieson began the manufacture of synthetic salt cake, a sintered composition of sulfur and soda ash. When shipments of by-product salt cake from Europe were cut off by the war, Mathieson supplied enough synthetic salt cake to make good the tonnage needed by the American kraft paper industry. During World War II, Mathieson operated the government-built ammonia plant at Lake Charles, producing synthetic ammonia from natural gas and atmospheric nitrogen. This plant was acquired under lease from the Government early in 1947 and again placed in full operation about the middle of the year. It was purchased from the Government in 1948, for $7,063,300.

In the early twenties the Mathieson research staff at Niagara Falls had begun work on a new chlorine carrier to serve a need neither bleaching powder nor liquid chlorine had satisfactorily met. This new product—high-test calcium hypochlorite containing over 70% available chlorine—was placed on the market under the trade name H T H. Later packaged specially for laundry bleaching as H T H Bleach and for water treatment as Sanitation H T H, it has been marketed in modified forms as Lo-Bax, for dairy, farm, and plant sanitation, and as HTH-15, a poultry disinfectant, dry chlorine inhalant for poultry dusting, and all-purpose chlorine sanitizing agent. Related products are Chromotex, for plant cleaning of rugs and carpets, and Neutrotone, for "location" cleaning of wall-to-wall, tacked-down carpeting. Another chlorine product developed at Niagara Falls is sodium chlorite, a new bleaching and oxidizing agent, the manufacture of which began in 1941. Known in the laboratory for nearly 100 years but never produced commercially, sodium chlorite possesses the unique ability of bleaching cellulosic fibers to a high degree of whiteness without attacking or degrading the fibers. Commercial application of sodium chlorite led to the development of another bleaching and oxidizing agent—chlorine dioxide—which is generated from sodium chlorite at the point of use. This new reagent, two and one-half times greater in oxidizing capacity than chlorine, is used in various bleaching and oxidizing operations and in the removal of objectionable tastes and odors in municipal water supplies. Dry sodium methylate, also recently developed at Niagara Falls, is a useful reagent in producing sulfa drugs, vitamins, dyes and pigments, perfumes, organic intermediates, and other products.

An important date in the Company's history is 1919. Until that time Mathieson was solely a manufacturing organization whose products were marketed through an exclusive selling agent in accordance with long-accepted practice in the heavy chemical industry; its activities were confined almost entirely to heavy chemicals—caustic soda, soda ash, bicarbonate of soda, bleaching powder, liquid chlorine. With the end of the war, the plants being run-down and unable to operate efficiently, the Company was faced with high production costs in a period of declining sales prices.

At this critical point, the directors, led by Galen L. Stone of Hayden, Stone & Co., decided on a complete reorganization. They invited the late Edwin M. Allen to assume the presidency, which he did in July 1919. From that time until his death on Nov. 2, 1947, Allen was identified with the development of the Company as president, chairman of the board, and director. A mechanical engineer and a graduate of Purdue University, he had been president of the Fayette Manufacturing Co. and the Basic Brick Co., and helped organize the American Refractories Co.

One of the first moves of the new management was to dispense with selling through an exclusive selling agent. Mathieson was the first alkali maker to sell direct through its own selling force. A comprehensive plant rehabilitation program

was initiated, traffic and technical service departments set up, and the Company's research and development facilities extended. Furthermore, a new policy of developing and marketing related chemical specialties was inaugurated and functions today.

Sales manager of the new Mathieson selling organization was the late John A. Kienle, prominent in the sanitary engineering field, who was largely responsible for the introduction of chlorine in the treatment of public water supplies. Associated with Kienle at that time was Esse E. Routh, now vice-president and director of sales, who started with the Company as an office boy at the Saltville plant. Also prominent in the Company's growth and still active in management are: Howard Berry, vice-president and treasurer; John V. Joyce, vice-president and controller; Donald W. Drummond, vice-president and general manager of sales; Arthur T. Bennett, vice-president and general manager of operations; Anson P. Winsor, secretary; Ralph E. Gage, technical advisor; Harry M. Mabey, general traffic manager; H. Webster Stull, counsel and personnel director; Eugene J. Parent, director of purchases; F. Boynton Butler, manager, Niagara plant; R. B. Worthy, manager, Saltville plant; and James F. Newell, manager, Lake Charles plant.

In the earlier history of the Company, Charles F. Vaughn, a vice-president at his retirement some years ago, was largely responsible for the successful development of the Castner process at Niagara Falls. During World War I, Vaughn was Lieutenant-Colonel in the Chemical Warfare Service in charge of the chlorine section at Edgewood Arsenal, and in 1939 was awarded the Schoellkopf medal for distinguished service in chemical engineering. Max Mauran, vice-president at the time of his death in 1928, was chiefly responsible for the design of the multi-unit chlorine gas tankcar and other early developments in connection with liquid chlorine and synthetic ammonia. The late James H. MacMahon, who retired some years before his death in 1944, was at one time manager of the Saltville plant and was later in charge of technical service during the period when industry was gradually switching from bleaching powder to liquid chlorine.

The success of Mathieson Chemical's management has been reflected in its net earnings over the past 28 years. Since 1921, when the full impact of its postwar difficulties was felt, Mathieson's net profits have stayed close to, or have risen well above, the million mark each year. Dividends on the common stock, after a lapse of six years, have been paid regularly since 1926.

Capitalization in 1947 consisted of preferred stock of $100 par value, of which 35,000 shares were authorized and 23,777 outstanding; and of common stock, no-par value, 1,000,000 shares authorized and 828,171 outstanding. Mar. 31, 1948, when the name Mathieson Chemical Corp. was approved to identify the Company with its increasingly diversified line of products, the issue of 500,000 additional shares of common stock was authorized. Retirement of all but the present outstanding shares of preferred stock was also approved.

The late George W. Dolan, who had been head of the Company from the time of E. M. Allen's retirement as president in 1944, was succeeded by Thomas S. Nichols, previously vice-president and director of the Prior Chemical Co. and prior to 1937 with du Pont. Nichols is now president and chairman of the board. John C. Leppart, who also came from Prior Chemical via Solvay Process Co., Pittsburgh Plate Glass Co.'s Columbia Chemical Division, and Southern Alkali Corp., joined Mathieson at the same time as Nichols and is executive vice-president. Recent additions to the management staff include Dr. D. P. Morgan who joined Mathieson as administrator of research and development and has been elected a vice-president; Dr. Carl F. Prutton, director of research, formerly head of the

Department of Chemistry & Chemical Engineering, Case School of Applied Science; and Sam L. Nevins, general manager of the Ammonia Department, coming from Southern Acid & Sulphur Co. Present directors are Howard Berry, Louis G. Bissell, H. Donald Campbell, Arnold B. Chace, John P. Chase, Leppart, Nichols, Sinclair Richardson, and Robert G. Stone.

Company plant property at the end of 1946 was valued at $42,862,223.47 before depreciation. A $20,000,000 plant expansion and modernization program, launched in the fall of 1945, is expected to be completed by the middle of 1948.

MELLON INSTITUTE is an endowed, nonprofit incorporated institution for research in the pure and applied natural sciences, for training research workers, and for providing technical information to the public. It grew out of a plan conceived by Dr. Robert K. Duncan in 1906 to make scientific research more available to the public and more applicable to industry. At the University of Kansas, in 1907, he evolved the Industrial Fellowship System under which a manufacturer could establish a temporary fellowship in a university for the investigation of a particular problem whose solution would benefit both him and the public. In 1910 Andrew W. Mellon and Richard B. Mellon asked Duncan to put it into practice at the University of Pittsburgh.

The idea was accepted with interest by industries and in 1913 a permanent organization was set up as the Mellon Institute. It remained a part of the University of Pittsburgh until 1927, when it was separately incorporated. Since then its affairs have been managed by an executive staff responsible through the director, Edward R. Weidlein, to its own board of trustees. The Institute cooperates with the University and the junior members of its research staff may be graduate students there. However, the researches of fellowships are of postdoctoral character, and the fellows and their aides on a salary basis.

The arrangement is as follows: A manufacturer seeking to investigate a problem, or hoping for general benefit from a research program, donates money for a temporary fellowship at the Institute. A fellowship agreement is drawn up between the Institute and the donor setting forth the purpose and the terms. The fellow selected must be acceptable both to the donor and the Institute. The donor has control over the research findings of the fellowship, their patenting and publication. The fellows often find later employment with their donors. The Institute defrays the overhead expenses not chargeable to a particular donor and the cost of equipment of general long-term use. It thus provides facilities for researches which if conducted individually would be much more costly. In addition, the physical separation of the Institute and its laboratories from production plants is regarded as a great advantage to long-range research.

Because it recognizes the need of fundamental scientific research as a background and source of stimulus for industrial research, the Institute also supports disinterested investigations not suggested by the industries but planned within the organization and made available to the public and the professions. Its Department of Research in Pure Chemistry studies chemotherapeutic problems, such as the synthesis of new drugs, and the Department of Research in Chemical Physics applies the new techniques of this field in assistance to fellowships and in fundamental studies of its own choice. Industrial Hygiene Foundation, a nonprofit national association of industries for advancing health in technology, operates under the Institute's auspices.

The Institute's beautiful and well-equipped building, the gift of the founders, Andrew W. and Richard B. Mellon, was dedicated May 6, 1937. Eighty fellow-

ships are now in operation, some of which have been renewed over a period of 30 years.

Notable industrial researches conducted at Mellon Institute have related to physical and chemical problems of abrasives, utilization of anthracite, antifouling paints, beet sugar technology, cane sugar derivatives, cork products, demolition bombs, bone products, bread technology, new uses for sulfur, carbon dioxide, common salt, and magnesium carbonate, catalysis, cellulose chemistry, storage of chemicals, by-product coking practice, bituminous coal chemical technology, coal-tar derivatives and synthetics, cyanogen chemistry, protective coatings, commodity standards, hydrometallurgy of copper, corn proteins, corrosion, cotton chemistry, causes of dental caries, dental cements, drug standards, dry cleaning and laundering, felt technology, major problems of fertilizer technology, betterment of fiber containers, flame throwers, novel flooring materials, food and beverage flavors, nutritional phases of food technology, foods, fungicides, fur technology, galvanizing practice, manufacture of industrial gases, natural gas technology, olefin gases and their derivatives, acetylene and ethylene chemistry, fundamentals of gelatin and glue technology, glass manufacture, industrial health, chemical hygiene, heat insulation, dehydrogenation and oxidation of hydrocarbons, improved inks, insect repellents and insecticides, improvements in cast and wrought-iron technology, life preservers, synthetic lubricants, magnesium alloys, meat tenderization, chemical mortar shells, new nickel compounds, ore flotation, new synthetic organic products, packaging, paper technology, petrolatum, petroleum chemistry and refining technology, new pharmaceuticals, utilization of waste pickle liquor, improved vitrified pipe, new plastics, novel porcelain enamels, powder metallurgy, pressure vessels, protected metals, rayon technology, refractories, constructional resins, resistors for electronic equipment, rubber, new rubber accelerators, synthetic rubber technology, styrene chemistry, cellulosic sausage casings, new cellulose products, silicone chemistry, sleep and better sleeping equipment, urban smoke and dust control, soybean technology, steel manufacture, stream improvement, sugar refining, synthetic fibers, tape technology, textile finishing, thread technology, collapsible tube manufacture, vitamin methodology, watch technology, water pollution control, welding practice, wheat products, wood preservation, yeast manufacture, and zinc metallurgy. Outstanding investigations in the Institute's Department of Research on Pure Chemistry have pertained to alloxan diabetes, new antimalarials, carbohydrates, cinchona alkaloids, drug standardization, glycol derivatives, new hydroxyethylating agents, pneumococcocides, chemotherapy of pneumonia, and new sedatives.

Scientists who have distinguished themselves in Mellon Institute through managing or participating as workers in important research programs include: R. R. Ackley (textile finishing), G. C. Akerlof (physical chemistry), F. O. Anderegg (ceramics), J. R. Anderson (analytical chemistry), H. L. Anthony (ferrous metallurgy), R. F. Bacon (petroleum chemistry), G. E. Barker (synthetic lubricants), E. P. Barrett (bone products), H. L. Barthelemy (rayon technology), L. W. Bass (research administration), N. J. Beaber (soybean technology), G. D. Beal (pharmaceutical chemistry; research administration), R. C. Benner (urban smoke control), D. G. Bennett (enamels), R. H. Bogue (gelatin and glue), M. C. Booze (refractories), J. R. Bowman (petroleum chemistry), R. C. Briant (rubber chemistry), F. P. Brock (plastics), B. T. Brooks (petroleum chemistry), R. H. Brownlee (industrial gases), W. B. Burnett (rubber accelerators), C. L. Butler (carbohydrate chemistry), E. S. Byron (powder metallurgy), L. A. Carapella (magnesium alloys), C. B. Carter (organic chemistry), E. J. Casselman (shaving), E. R. Clark (textile science), A. W. Coffman (metallic adhesives),

S. S. Cole (refractories), H. S. Coleman (research laboratory design, erection, and equipment), H. W. Coles (organic chemistry), B. B. Corson (coal chemistry), M. D. Coulter (meat technology), L. E. Cover (cork technology), G. J. Cox (sucrose derivatives; dental caries), L. H. Cretcher (basic chemotherapy; organic chemistry; research administration), G. O. Curme (olefin gases and derivatives), P. B. Davidson (paper technology), Melvin De Groote (food flavors), T. B. Downey (gelatin), W. W. Duecker (sulfur), R. K. Duncan (research administration), H. G. Elledge (laundering), P. H. Emmett (physical chemistry), J. J. Enright (dental caries), W. F. Fair (rheology), W. F. Faragher (petroleum chemistry), P. D. Foote (petroleum production), J. B. Garner (natural gas), W. L. Glowacki (by-product coke technology), C. F. Goldthwait (textile chemistry), H. W. Greider (rubber compounding), J. M. Grim (plastics), W. A. Gruse (petroleum chemistry), W. A. Hamor (chemical economics; research administration), W. E. Hanson (petroleum chemistry), E. R. Harding (food technology), A. W. Harvey (fur technology), T. F. Hatch (industrial hygiene), O. F. Hedenburg (insecticides), R. H. Heilman (heat insulation), D. F. Helm (welding science), W. C. L. Hemeon (industrial health engineering), W. F. Henderson (cellulose chemistry), Harold Hibbert (organic chemistry), W. H. Hill (by-product coke technology), R. D. Hoak (steel industry wastes), W. W. Hodge (sanitary chemistry), F. R. Holden (industrial hygiene), A. M. Howald (plastics), R. M. Howe (refractories), D. S. Hubbell (floorings), W. J. Huff (coke-oven tar), W. G. Imhoff (galvanizing), L. E. Jackson (dry cleaning; mothproofing), G. H. Johnson (laundering), H. M. Johnson (sleep), C. L. Jones (carbon dioxide), J. W. Jordan (plastics), E. G. King (life preservers), H. P. Klug (chemical physics), H. A. Kohman (bread), Jules Labarthe, Jr. (textile science), L. L. Lachat (nutrition), R. H. Lester (watch technology), D. C. Lewis (organic chemistry), C. J. Livingstone (engine fuels and lubricants), W. S. McClenahan (petrolatum), J. R. McDermet (turbine technology), R. R. McGregor (silicones), E. R. McLean (textile chemistry), J. F. McMahon (industrial hygiene), J. D. Malcolmson (fiber container technology), E. E. Marbaker (ceramics), H. B. Meller (urban smoke and dust control), D. F. Menard (tube technology), H. H. Meyers (fertilizer technology), R. W. Miller (natural gas), W. L. Nelson (organic chemistry), R. F. Nickerson (cotton chemistry), C. L. Perkins (ore flotation), S. M. Phelps (refractories), A. R. Powell (by-product coke technology), D. S. Pratt (organic chemistry), L. V. Redman (plastics), E. W. Reid (olefin gases and derivatives), A. G. Renfrew (organic chemistry), R. V. Rice (pharmaceutical chemistry), H. J. Rose (solid fuels), A. E. Ruark (physics), S. R. Scholes (glass technology), H. G. Schurecht (sewer-pipe technology), E. W. Schwartze (pharmacology), J. A. Shaw (analytical chemistry), H. F. Smyth, Jr. (chemical hygiene), F. W. Sperr, Jr. (by-product coke technology), E. E. Stahly (synthetic rubber), D. R. Stevens (petroleum chemistry), W. W. Strong (electrical precipitation), T. H. Swan (textile science), W. Swietoslawski (physical chemistry), A. F. Tesi (commodity standards), A. P. Thompson (abrasives), E. W. Tillotson (ceramics; research administration), R. S. Tipson (organic chemistry), D. K. Tressler (marine products), C. C. Vogt (dental chemistry), R. L. Wakeman (plastics), E. L. Warrick (silicones), E. R. Weidlein (hydrometallurgy; research administration), A. J. Weith (plastics), J. H. Wells (by-product coke technology), R. N. Wenzel (fatty acids), B. B. Wescott (wrought iron), B. G. Wilkes (organic chemistry), P. J. Wilson, Jr. (by-product coke technology), T. A. Wilson (textile chemistry), G. H. Young (corrosion; protective coatings), and J. H. Young (protected metals).

MERCK & CO., INC., and its predecessor companies virtually summarize the development of chemical manufacture in America. Their origins date back to 1818, two years prior to the discovery of quinine. The establishment of the business under the Merck name, however, took place in 1891, when George Merck, a young man of 24, came to the United States from Darmstadt, Germany. He organized the firm of Merck & Co., with offices at 71 William St., N. Y. City, by forming a partnership with Theodore Weicker who had preceded him from Darmstadt in 1887. The partnership continued until 1904, when Weicker retired. In 1908 George Merck, who had become an American citizen, incorporated the business in New York with a capital of $250,000 and an issue of $750,000 debentures. Nine years later the capital stock was increased to $1,000,000 and the debentures were retired.

In the beginning, Merck & Co. was largely devoted to the importation of drugs and chemicals, including the products of the firm of E. Merck (Chemical Works) in Darmstadt, of which George Merck's father, Wilhelm Merck, was at that time head. A few years later, the newly organized American business became an independent manufacturing enterprise and subsequently produced an extensive line of drugs and chemicals. The origin of the firm of E. Merck was the 17th century pharmacy, *At the Sign of the Angel,* in Darmstadt, which came into the possession of Friedrich J. Merck in 1668 and has remained in the Merck family for almost 280 years. Heinrich E. Merck, grandfather of George Merck, took over in 1816 and, as intimate friend and collaborator of Justus von Liebig, started on the road from pharmacy to factory. The preparation of pure alkaloids was the main objective of the founder and his many achievements included the original manufacture on a commercial scale of morphine in 1827, codeine in 1836, and cocaine in 1862.

In 1896 Merck & Co. moved to the Merck Bldg. at University Place and Eighth St., N. Y. City, and three years later acquired about 150 acres at Rahway, N. J., extending along the Pennsylvania R.R. Shortly thereafter, it began to manufacture chemicals in a single building, which is still in use today, and gradually expanding its facilities, Merck became a leading producer of chloral hydrate, iodine preparations, bismuth salts, acetanilide, narcotics, salicylates, alkaloids, disinfectants, and other important products, including a comprehensive line of prescription, photographic, and reagent chemicals. In 1903 the manufacturing chemical business of Herf & Frerichs at St. Louis was purchased and later became the St. Louis branch. In 1911 Merck opened a Canadian branch office at Montreal. At that time the main offices of the Company were at 45 Park Place, N. Y. City.

From 1914-18 sales almost doubled in volume, to $8,000,000. The original investment in buildings, machinery, and equipment had trebled in value, and the net assets had grown from $150,000 to $2,400,000. The property in Rahway and the adjoining town of Linden had been extended to 170 acres, about 35 of which were occupied by the plant, which consisted of about 40 buildings. There was also a small plant at Midland, Mich.

At the beginning of World War I, George Merck voluntarily turned over to the Alien Property Custodian an adequate amount of common stock to cover the interest in his company held by relatives to Germany. In 1919 this stock was sold by the Custodian to a group headed by Goldman, Sachs & Co. and Lehman Bros., with Sullivan & Cromwell as counsel. Together with George Merck, they worked out recapitalization through a sale of preferred stock to the public which eliminated the German interests and kept him in control of the business. During and following World War I, Merck & Co. continued to grow. In 1926 the main offices

were moved to Rahway, N. J., and a New York office was maintained at 64 Park Place. The Rahway manufacturing facilities continued to expand.

In 1925, warned by failing health, George Merck became chairman of the board and was succeeded as president by his son, George W. Merck. Born in N. Y. City, Mar. 29, 1894, George W. Merck had entered the firm immediately following graduation from Harvard in 1915. By 1925 he had acquired a thorough, practical knowledge of the business.

Unfortunately, the reward of more leisurely days were not to be enjoyed by George Merck, for he died at the age of 59, at his home in Llewellyn Park, West Orange, N. J., Oct. 21, 1926, with many personal tributes and editorial comments on his passing. *Chemical Markets* stated that "Competitors and customers alike have testified to his high ideals, energy, culture, and modesty—those of a true gentleman of the Old School."

July 1, 1927, Powers-Weightman-Rosengarten Co., Philadelphia, was consolidated with Merck & Co., under the name of Merck & Co., Inc. Perceiving the benefits to be derived from a combination of the assets and facilities of two outstanding producers of fine chemicals, George W. Merck and Frederic Rosengarten arranged a plan of consolidation that was unanimously approved by stockholders of both companies. P-W-R and its predecessors go back to 1818, when John Farr, in Philadelphia, was investigating cinchona bark. Before his studies were completed, the French pharmacists Pelletier and Caventou announced the discovery of the principal cinchona alkaloid, quinine, in 1820. Farr and his partner, Kunzi, commenced the production of quinine in 1822. In 1838 the firm name of Farr & Kunzi was changed to John Farr & Co., and in 1841 Farr brought in his nephew, William Weightman, and Thomas H. Powers, to establish Farr, Powers & Weightman. When Farr died in 1847, the firm changed to Powers & Weightman.

Contemporaneously with these developments, in 1822, a Swiss chemist named Zeitler, from a German canton, and another, Seitler, from a French canton, had a small chemical manufacturing business in Philadelphia. One could not speak French and the other could not speak German; neither spoke English. To settle their difficulties they called upon George D. Rosengarten (1801-90), who was fluent in all three languages, to settle their disputes. Rosengarten soon took over Seitler's interest and within a short time bought Zeitler's. His business prospered, particularly after he employed a young French chemist, N. F. H. Denis, in 1835, with whom he formed a partnership in 1840 (Rosengarten & Denis). Denis, a former pupil and coworker of Robiquet, was a scientist of unusual attainments. He retired in 1853 and returned to France. In 1854 Rosengarten's two sons, Samuel G. (1826-1908), who had studied in Germany under Liebig, and Mitchell G. (1829-98) were admitted to the partnership, the firm from then on becoming Rosengarten & Sons. Later another son, Adolph G. Rosengarten, who lost his life in the Civil War, as well as Harry B. and Frank H. Rosengarten, became partners. Eventually, Harry B. Rosengarten (1837-1921) became the sole surviving partner and in conjunction with his sons, George D. Rosengarten, Jr. (1869-1936), Adolph G. Rosengarten (1870-1946), Joseph G. Rosengarten, Jr. (1875-), and Frederic Rosengarten (1877-) continued the business under the name of Rosengarten & Sons, Inc. On Jan. 1, 1905, the Rosengartens acquired the business of Powers & Weightman and thus formed the Powers-Weightman-Rosengarten Co., which merged with Merck.

Contemporaneously with this consolidation, the former Merck & Co. changed its name to the Merck Corp., and P-W-R became the Falls Co., both continuing as holding companies of stock in the newly formed Merck & Co., Inc. A new company was incorporated in Pennsylvania as the Powers-Weightman-Rosen-

garten Corp., a wholly owned subsidiary of Merck & Co., Inc. In 1934 the Merck Corp. and Merck & Co., Inc., were consolidated in New Jersey and New York to form the present-day firm of Merck & Co., Inc. Subsequently the Falls Co. distributed its holdings of Merck stock to its stockholders.

The newly combined organization in 1927 was headed by George W. Merck, and Frederic Rosengarten became chairman of the board. George W. Perkins, son-in-law of George Merck, was elected treasurer and director, and subsequently executive vice-president. The other officers were: James J. Kerrigan, R. E. Gruber, Joseph G. Rosengarten, Jr., and Joseph Rosin, vice-presidents; H. R. Neilson, secretary; P. McK. Garrison and S. W. Walker, assistant secretaries; Henry Stein, assistant treasurer; B. L. Murray, chief chemist; and J. A. Garvin, assistant to the president. Directors included Waddill Catchings, Richard E. Dwight, E. H. Green, Adolph G. and George D. Rosengarten, in addition to the three senior officers.

In 1933 Merck & Co., Inc., dedicated new and enlarged laboratories and the Merck Institute for Therapeutic Research was founded and incorporated in New Jersey as an independent, nonprofit organization. The Research Laboratories provide modern facilities for research in organic chemistry, biochemistry, physical and inorganic chemistry, microbiology, process development, and chemical engineering. In addition, special laboratories are maintained for microanalyses, cereal chemistry, textile chemistry, entomology, research on container problems, and customer research. Merck has maintained fellowships, scholarships, and grants at various colleges, universities, and institutions throughout the United States which are devoted to research in various fields. In Nov. 1946 a $100,000 fund was established with the National Academy of Sciences to assist young scientists in chemical and biological research.

Since 1934 the name Merck has been identified with leadership in the synthesis, development, and large-scale production of vitamins. Vitamin B_1, vitamin B_6, vitamin E, pantothenic acid, and biotin were synthesized by Merck chemists and their collaborators. In addition, processes were developed by which ascorbic acid, riboflavin, niacin, niacinamide, calcium pantothenate, vitamin K_1, and menadione were made commercially available. One of the pioneer manufacturers of sulfanilamide, Merck was first to produce sulfapyridine in the United States after its development in England, and later became a leading large-scale producer of sulfathiazole and other sulfa drugs. Merck laboratories developed the rapidly acting anesthetic, Vinethene; introduced a successful process for the synthesis of ephedrine; and were in the forefront in the developement of penicillin and streptomycin.

For many years Merck & Co., Inc., has issued standard textbooks and other publications, *The Merck Manual of Therapeutics and Materia Medica; The Merck Index,* an encyclopedia of chemicals and drugs; *The Merck Report,* a quarterly on pharmacy and medicine. It has also published numerous booklets as part of its professional service, such as "The Story of Vitamin B_1," "The Story of Penicillin," etc., and annotated bibliographies.

The main plant, laboratories, and offices of the Company are in Rahway, N. J. The plant consists of more than 100 buildings, containing 1,000,000 sq. ft. of floor space, and occupying approximately 70 acres, of which 43 are in Rahway and 27 in Linden. The total property comprises 197 acres. The East Falls plant on the Schuylkill River, near Philadelphia, consists of 46 buildings and comprises about 25 acres. The Stonewall plant is located on a 400-tract in the Shenandoah Valley, near Elkton, Va., acquired in 1941, upon which about 25 buildings have been erected.

The more important groups of products manufactured at the three plants are synthetic vitamins, antibiotics, sulfonamides, alkaloids—including opium and cinchona derivatives—and insecticides such as DDT. Others include arsphenamines, bismuth, citrate, iodide, and silver salts, laboratory reagent chemicals, prescription chemicals, amino acids.

Branch offices and warehouses are located in New York, Philadelphia, St. Louis, Chicago, and Los Angeles. In 1930 the New York office and warehouse were moved from 145 Front St. to 161 Avenue of the Americas and 12 Van Dam St. In 1911 the Company established a Canadian branch office and warehouse in Montreal. In 1929 Merck & Co., Ltd., was incorporated with an announcement of its intention to produce "Made-in-Canada" chemicals and next year started manufacturing at 560 Decourcelles St. to which address it moved its offices. A sales office also was established at Toronto. In 1946 two new factories were completed on 200 acres at Valleyfield, Quebec, to supplement the Company's rapidly expanding requirements.

Experimental Plantations, Inc., was organized in 1939 as a wholly owned subsidiary to propagate tropical plants of interest to the Company, on plantations in Guatemala and Costa Rica. N. V. Cultuur Maatschappij "Tjitembong," a wholly owned subsidiary, was acquired in 1932 to operate a coca leaves plantation in Java. P.W.R. Export Corp. was established in 1946 to handle the export business of Merck & Co., Inc., in countries outside the United States and Canada.

Merck & Co., Inc., played an important part in World War II by supplying vital drugs and chemicals to our Armed Forces and Allies, as well as to civilians on the home front: penicillin, streptomycin, Atabrine, narcotics, sulfa drugs, anesthetics, vitamins, DDT, and other products.

Merck pioneered in the development of penicillin. Intensive research, begun in the autumn of 1940, established a sound basis for successful mass production. In 1941 Merck helped to bring about a reciprocal arrangement between British and American investigators to spur production in cooperation with the U. S. and British Governments. In 1942 it supplied penicillin for the first case of bacteremia successfully treated with this drug in the United States and next year sent it to England by air transport for use by the U. S. Army Medical Corps. By 1944, Merck was sending ever-increasing supplies of penicillin to our Armed Forces on all fronts, and the new penicillin plant of its Canadian subsidiary, which had been assembled in six weeks, was operating successfully and delivering substantial quantities to the Canadian Government. In the spring of 1945 production of penicillin had reached a point where additional supplies were being shipped to hospitals, wholesale druggists, and physicians' supply houses for civilian medical needs. In 1946 Merck began supplying quantities of crystalline penicillin G sodium, one of the pure active factors of the original product.

Streptomycin was first produced in the Merck Laboratories in 1944. The following year engineering plans were started for a large-scale plant, and within nine months the first shipment of streptomycin was made from the new unit, a project acclaimed as one of the outstanding achievements in the American chemical industry. Another achievement was DDT whose tonnage production Merck began expanding early in 1944, at the request of the Government. Subsequently it became a basic source of supply for manufacturers using this product in formulating insecticides. During the war the activities of the Merck Laboratories and Institute for Therapeutic Research were closely coordinated with the Government's research program.

George W. Merck served as special consultant to the Secretary of War, and as chairman of the U. S. Biological Warfare Committee. George W. Perkins was

Colonel in the Chemical Warfare Service. Several other executives carried out special assignments for the Government. Early in 1943 each of the three Merck plants was awarded the Army-Navy "E" for excellence in production. Successively, the workers in the Merck factories received four white stars for their "E" flags, a total of five awards for each plant. In 1944 the Rahway and Elkton plants also received the National Security award.

Due largely to intensive research and the development of new manufacturing techniques, Merck & Co., Inc., has grown steadily during the past three decades. In 1939 sales were more than $20,000,000, and in 1947 in excess of $68,000,000. In 1940 approximately $1,000,000 was expended for research and development, and that amount has been substantially increased each year, reaching $3,400,000 in 1947.

The capitalization of the Company consists of 120,000 shares of no-par, cumulative, $3.50-dividend preferred stock, and 1,'00,000 shares of common stock, par $1. On May 15, 1946, both stocks were admitted to trading on the N. Y. Stock Exchange. A conservative dividend policy has been pursued, in order to reinvest a substantial portion of earnings in new equipment and buildings, and in additional research and manufacturing facilities. Merck & Co., Inc., is owned by approximately 5,000 stockholders. It is controlled and managed by citizens of the United States and, with the exception of its Canadian subsidiary and a British subsidiary now in process of formation, it has no connections with any firm of similar name.

The officials are: directors, Frederic Rosengarten, chairman; Henry D. Dakin, Edward H. Green, Henry W. Johnstone, James J. Kerrigan, George W. Merck, Harry R. Neilson, George W. Perkins, Edward Reynolds, Adolph G. Rosengarten, Jr., and Walter E. Sachs; president, Merck; vice-presidents, Kerrigan and Johnstone; vice-president and scientific director, Randolph T. Major; vice-president for foreign relations, Rudolf E. Gruber; treasurer, John H. Gage; controller, Raymond E. Snyder; secretary, John T. Connor; assistant to president, Carl M. Anderson; assistant treasurer, Walter G. Suffern; assistant secretaries, Reverdy Johnson, John F. Neill, and Lars J. Sandberg.

MICHIGAN CHEMICAL CORPORATION'S formation at St. Louis, Feb. 21, 1935, was prompted by three chief circumstances. First, the growing domestic and foreign market for bromine and its salts; second, the development of Michigan oil fields which yielded data on the composition, location, and abundance of the state's brine deposits; third, experience in developing chemical brines.

Founders and original officers of the Corporation were Walter B. Wilkinson, president and treasurer; Donald H. Wilkinson, vice-president and secretary; and John L. Giles, vice-president and general manager. Together with Richard P. Lyman, they comprised the board of directors. Giles supplied the chemical engineering experience for the group. He had built and operated salt plants for the Ruggles & Rademaker Salt Co. and Manistee Salt Works at Manistee, Mich., had explored the brine strata, and introduced the bromine industry in Manistee.

St. Louis was chosen because of its inexhaustible supply of brines rich in bromides, calcium chloride, magnesium chloride, and common salt. A plant on a 14-acre site was constructed during the winter of 1935-36, for the manufacture of bromine, sodium bromide, potassium bromide, and salt. Operations began in May 1936 with about 55 employees. The process differs from others in the area in that the brine is first evaporated to remove salt, after which bromine is extracted from the concentrated bittern in Kubierschky-type towers. The chemical composition of the brine and its low sulfate content favor this method, as well as

the production of calcium and magnesium chloride brines for use on highways, coal treatment, and other purposes.

The early decision to market special purified grades of salt to consumer outlets led to the organization of Michigan Salt Co., a sales affiliate, in Mar. 1937. Salt production has been expanded from 50 tons a day to 150 tons. Ammonium bromide was added in 1938; hydrobromic acid and pelleted sodium and potassium bromides in 1939. Full-time research was instituted on Dec. 1, 1939, and during 1940 a complete line of bromides was developed, including methyl, ethyl, butyl, allyl, barium, calcium, and iron bromides, and bromoform.

In June 1941 a group of financiers, headed by William T. Morris and Col. T. Colburn Davis, acquired a large interest and from this point the Corporation's growth was accelerated. Late that year, a $700,000 magnesia plant was constructed and by Aug. 1942 was furnishing refractory grades of magnesia for war use. A year later, a special grade of magnesia for rubber compounding was produced to meet urgent military needs. During this period the Corporation was entirely in war production, also making large quantities of methyl and other organic bromides. A radical departure from brines as raw material was made in Aug. 1944, when the Corporation began the manufacture of dichloro-diphenyl-trichloroethane (DDT). It decided to enter the consumer market with DDT insecticide after the military needs were fulfilled.

In Oct. 1945, Harold van H. Proskey, formerly sales manager of Lehn & Fink Products Co., was appointed director of sales and advertising, with offices in New York, where an Eastern sales branch was established. During World War II the number of employees at Michigan Chemical rose to 475 and sales increased tenfold. Since the end of the war, 2,4-D and several important new bromides have been added to the Company's list which now comprises about 30 products.

Heading Michigan Chemical is T. Colburn Davis, elected to succeed William T. Morris who died in Feb. 1946. Davis had already served as executive vice-president and took a leading part in shaping the Corporation's policies during and after the war. Other officers and directors are R. A. Bondurant, Jr., vice-president and general manager; Robert L. Wilson, secretary and general sales manager; Russell Knapp, treasurer; Clarence G. Woods, comptroller; H. C. Wohlers, technical director. Directors are Davis, Bondurant, Wilson, Gene Tunney, Cyrus N. Johns, Wilmot F. Wheeler, R. E. Brownell, C. S. Mott, C. Wetherald, and J. H. McMullen.

MIDWEST RESEARCH INSTITUTE developed after long, thorough investigation of the needs for well-organized research in this part of the country, when nine of the individuals who financed the study applied for a non-profit charter. The Institute was incorporated on June 17, 1944, by Robert L. Mehornay, B. C. Adams, Paul D. Bartlett, Roy Cross, J. C. Nichols, C. J. Patterson, Kenneth A. Spencer, J. F. Stephens, and C. T. Thompson. In July, with $500,000 subscribed by business concerns and individuals, the Institute began limited operations in Kansas City under the direction of Dr. W. T. Rinehart, on leave from the Armour Research Foundation, Chicago. The Institute officially began operations Jan. 1, 1945, with the appointment of Harold Vagtborg as president and director. Director of the successful Armour Research Foundation from its beginning, Dr. Vagtborg had been advisor to the Midwest Research Institute in its formative period.

From the beginning the Institute had two main objectives: First, to conduct industrial research for companies and associations, giving the sponsor full patent

protection and prosecuting the work in the degree of confidence required by him. Second, to work for the economic advancement of Mid-America through the application of science and technology to the development of its natural resources. Although known as the agricultural center, Mid-America abounds in coal, petroleum, natural gas, and minerals. The Institute's first project was a problem in postwar conversion, sponsored by the Military Chemical Works, Inc., now Spencer Chemical Co., to find a coating for ammonium nitrate crystals which would prevent clumping and render this explosive useful as fertilizer. Since then 69 major research projects involving all fields and 118 short-term investigations have been undertaken.

From two laboratories and two offices, made available through the cooperation of the Campbell Taggart Research Corp., in a building located in historic Westport, the Institute has expanded its operations until it now temporarily occupies three commercial-type buildings and two residences. The laboratories and service departments established are agricultural chemistry, organic chemistry, inorganic chemistry, applied physics, engineering mechanics, carpentry and woodworking shop, drafting department, and instrument and machine shop. The Institute's library cooperates closely with the Linda Hall Library of Sciences and Technology.

Although the Midwest Research Institute is only two and one-half years old, it can report a number of valuable developments. Early in 1947 it developed for the Spencer Chemical Co., a commercial method of coating ammonium nitrate. Corn Products Refining Co. has decided to commercialize the processing of milo sorghum grain to produce starch and its many derivatives. This project was the outgrowth of collaboration between the laboratories of the company, the Institute, and the agricultural departments of Kansas State College, University of Nebraska, Oklahoma A & M College, and Texas A & M College, which have been doing the plant breeding. Industrial utilization of this grain not only creates another market for a crop heretofore grown exclusively for animal feed, but it also provides an alternate crop for wheat areas. For the Gustin-Bacon Manufacturing Co., the Institute has demonstrated a commercial method of producing glass fibers in quantity.

The comprehensive survey and analysis of major natural resources of the Missouri River Basin completed recently for the U. S. Army Corps of Engineers and released by it, makes available for industrial consideration a wealth of new information and has created great interest in surveys of this type. A project for Indiana Steel Products Co. on magnetic paper tape recorders has resulted in several commercially feasible models utilizing the magnetic powder tape manufactured by this company.

Projects directed toward regional welfare, financed by individuals and business organizations, makes the Midwest Research Institute unique in public service. A technical advisory committee of the trustees meets from time to time to select, establish, and budget suitable regional projects and counsel on their progress. The following projects are now under way: (1) development of agricultural fibers for industrial uses; (2) relation of properties of wheat to the baking properties of flour; (3) improvement of regional ceramic and refractory clays; (4) provision of latest techniques and instrumentation, including electronics, as a service to the regional industries; (5) preparation of valuable products from forest and mill wastes; (6) improvement of wood properties through chemical treatment; (7) inexpensive surface-hardening treatment for barn and feed lots; (8) improvement and retention of nutritive value of green hay; (9) compilation of six-state regional resources map; (10 nonfuel uses of petroleum and natural gas; (11) beneficiation of the marginal ores of the region; (12) survey of Arkansas and

Oklahoma coal; (13) preliminary exploration of staff ideas that might lead to patentable developments.

Trustees now (1947) number 171 representative leaders in agriculture, industry, commerce, the professions, education, and the technical and public press. They meet once a year to discuss general policies and elect a board of governors of 21 members who convene semiannually and who are responsible for control and management. The present board is as follows: Robert L. Mehornay, honorary chairman; B. C. Adams, T. H. Barton, W. J. Breidenthal, C. F. Byrns, E. L. Clark, G. L. Cross, Harry Darby, W. G. Green, John H. Kane, Deane W. Malott, Fred Maytag II, J. C. Nichols, C. J. Patterson, James L. Paxton, Jr., Joe W. Seacrest, Craig R. Shaeffer, Kenneth A. Spencer, J. F. Stephens, T. J. Strickler, and Harold Vagtborg. Six of the nine original incorporators serve as governors. The Institute has acquired for its permanent home a 10-acre site in Kansas City's Cultural and Scientific Center in close proximity to the new Linda Hall Library of Sciences and Technology, the University of Kansas City, and the William Nelson Rockhill Art Gallery.

MILES LABORATORIES, INC., was formerly the Dr. Miles Medical Co., founded in 1880 by Dr. Franklin Miles, a pioneer nerve specialist. Dr. Miles spent 12 years in study in colleges and universities and in hospital research work. He used the formula from which Miles Nervine was made with unusual success during the first few years of his practice and became convinced of its effectiveness. Norris E. Felt and Hugh McLaughlin associated themselves with Dr. Miles and began marketing his formula, whose active ingredients are bromides, under the name of Dr. Miles Nervine. Today Miles Nervine is still in active demand.

In 1885 the business was incorporated and a limited amount of stock sold. In 1887 Felt and McLaughlin sold their interests to George E. Compton and A. R. Burns and in 1889 A. R. Beardsley purchased part of Burns' interest and became the Company's secretary-treasurer. The balance of Burns' interest was bought in 1891 by A. H. Beardsley, who became secretary of the Company and, on the death of Dr. Franklin Miles in 1928, its president. In 1920 A. L. Beardsley joined the Company as general manager. He served as its president from 1936 until his death in Jan. 1944. Charles S. Beardsley joined in 1926, becoming vice-president in charge of sales and advertising in 1936, president in Jan. 1944, and chairman of the board in 1947.

As time went on, the Company introduced other preparations in keeping with the trend of current medical opinion. Of these, liquid Nervine, the original preparation, Anti-Pain Pills, which were introduced in 1893, and Effervescent Nervine Tablets first made in 1927, are still in active demand. Alka-Seltzer was marketed in 1930 and has the largest sales of any medicinal product developed in recent years. In 1939 research was started on vitamins. One-A-Day (brand) A & D Tablets, the first vitamin preparation made especially for sale to the general public, was put on the market in 1940. One-A-Day (brand) B-Complex Tablets were distributed to the drug trade in 1942, One-A-Day (brand) Multiple Capsules in 1943.

From a modest beginning, in this case Dr. Miles' own office and home, Miles Laboratories grew until in 1935 a greatly increased amount of space was needed. Further expansion of the original site was impossible, so a modern plant and a tract of land in the northwest part of town were purchased. Part of the Company's operations was moved to this new location. In 1937 a thoroughly modern building adjoining the new plant was erected and equipped. The entire office and manu-

facturing plant were moved here in 1938. In 1944 a building connected by tunnel with the main plant was remodeled and an up-to-date laboratory installed. Today Miles Laboratories is housed in a completely modern building having 9.6 acres or more than 417,000 sq. ft. operating space.

The Export Department was organized in Dec. 1935, when Miles was doing a certain amount of business in Canada and a few Latin-American countries. Today, the home office at Elkhart, Ind., ships to 46 foreign countries. Products for the Canadian trade are manufactured by Miles Laboratories, Ltd., Miles Bldg., Toronto. The United Kingdom, Australia, and some parts of the British Empire, as well as Egypt and other countries in the sterling area, are supplied from Miles Laboratories, Ltd., at Bridgend, Wales.

Ames Co., Inc., ethical branch of Miles, was organized in 1930 as Effervescent Products, Inc., with offices at 819 McNaughton Ave., Elkhart, Ind. In 1945 Ames purchased J. D. Riedel-E. de Haën, Inc., from the Alien Property Custodian. The pharmaceutical specialties manufactured by the combined companies are in the fields of effervescent tablets, diagnostic reagent tablets, bile acid, and barbiturates. They include such trade-named products as Clinitest, Hematest, Acetyl-Vess, Alka-Vess, Bromo-Vess, Salici-Vess, Cholmodin, Decholin, Decholin Sodium, Pernoston, and Sigmodal. The Sumner Chemical Co. of Zealand, Mich., manufacturers of several basic chemical specialities used by other manufacturing chemists, was purchased in 1948.

The present officers of Miles Laboratories, Inc., are: Charles S. Beardsley, chairman of the board; Walter R. Beardsley, president; Edward H. Beardsley, executive vice-president; Francis E. Compton, Dr. Walter A. Compton, and William E. Koerting, vice-presidents; Walter R. Lerner, secretary; Franklin B. Miles, treasurer; John A. Cawley, assistant secretary; and Robert L. Grant, assistant treasurer.

MINNESOTA MINING AND MANUFACTURING COMPANY in 1947 continued to grow for the 45th consecutive year, having matured from a small abrasive-mining concern to the largest manufacturer in St. Paul, nationally recognized in a dozen widely diversified fields; from a handful of men to thousands of employees with branch offices and plants throughout the United States. This achievement has been made possible by technical specialists and an aggressive effort by the Company to explore and exploit new fields.

3M began at Two Harbors, Minn., in 1902. Two local men—Hermon H. Cable, a realtor, and John Dwan, attorney—formed the Company with additional financial help from three Duluth men—a doctor and two railway men—to develop a deposit of corundum on the north shore of Lake Superior. Prior to this time, commercial quantities of corundum had only been mined in Ontario in a small way for use on grinding wheels and in sandblasting. 3M's founders believed that this only known United States deposit could replace emery as the standard abrasive mineral, so they set up a screening mill at Crystal Bay and hired a crew to dig ore. Fishing boats carried the mineral to Duluth, where it was transferred to larger vessels and shipped to abrasive products manufacturers in the East. The original enterprise was not successful; the mineral was inferior to Canadian corundum and markets did not materialize. Besides, a chemist in Niagara Falls discovered a synthetic abrasive, called Carborundum, better than corundum, and it replaced the natural mineral almost overnight.

Reorganizing, the founders sold a major share of 3M to L. P. Ordway, a St. Paul plumbing supply manufacturer, and E. B. Ober, then general freight agent for the Omaha railway. It was decided that the stockpiles of corundum could be utilized

for making sandpaper. An old flour mill in Duluth was converted for production, and Ober elected president. The corundum was not even good enough for this purpose, and the garnet and emery eventually used had to be imported. Even more discouraging was the damp, cold climate in Duluth; the sandpaper did not dry properly and did not perform as it should.

By 1909 sales were up a little, for 3M was making garnet and emery paper just the way the competitors were, but shipping costs were high. Archibald G. Bush, now vice-president and director of sales, started with the Company at this time as a cost accountant, but was soon transferred to sales. Associated with him were R. H. Skillman, later vice-president, and A. F. O'Brien, subsequently division manager at Boston. In 1910 it was decided to move to St. Paul, where Ordway financed the first building, which marked the turning point. One of 3M's first attempts better to serve industry was the effort in 1912 of William L. McKnight, who joined 3M in 1907 as a bookkeeper and was salesman in Iowa and Illinois, to learn more about the use of abrasives in the manufacture of furniture, which led to improvements in 3M products and slowly increasing sales.

Previous to World War I, another electric-furnace synthetic abrasive had been developed, superior to all types previously known. 3M devised a method for applying aluminum oxide to cloth without losing the flexibility of the fabric. The first 20 rolls of the new product, Three-M-ite cloth, were delivered to Detroit to be used in the auto industry, and in 1915 grinding disks came forth into the line. War production gave great impetus to growth, and in 1916 the first order in carload lots was received from the Curtis Airplane Co. in Buffalo. An additional building was completed in 1919. A second "maker" for abrasives went into operation and the sales crews grew. Louis F. Weyand, now vice-president in charge of the adhesives and coatings division, joined Bush in Chicago, and a general sales office was established in Philadelphia. By 1920, 3M had representatives all over the United States.

A printing ink manufacturer in Philadelphia, Francis G. Okie, had done some experimenting on waterproof sandpaper for submerged sanding. 3M purchased his patents and in 1921 Wetordry was marketed, the first 3M product of what can be termed research.

In 1925 the automotive industry again provided a challenge, for improved processes were essential for the spray-painting of two-tone bodies. To mask off areas not to be painted, gummed tapes were used which had to be soaked and scraped off after each job was completed. This problem was studied in the 3M laboratories, and credit for producing a successful masking tape in 1927 goes to Richard G. Drew, who combined a specially treated paper backing with an adhesive principally of glue and glycerin. This pressure-sensitive adhesive, however, was not completely satisfactory. Experiments on rubber-base adhesives resulted in more efficient adhesives. Synthetic rubber, which had to be substituted for natural during World War II, now plays a large part in this field. Rubber was again called upon to give the fibrous backings of masking tapes greater durability and resistance to moisture, and 3M found ways to put rubber and synthetics to work in still another capacity for paper treatments. Drew, in 1929, also produced transparent cellulose tape, the first product whereby cellophane bags could be sealed without punching holes in them. This transparent tape is now the best known and most widely used of the more than 100 varieties of "Scotch" brand tape in the 3M Co. line.

By 1929 remarkable progress had been made. McKnight had been elected president following the retirement of Ober. The organization was reincorporated under the laws of Delaware, in that year. George H. Halpin, now vice-president

and general sales manager, and A. H. Stewart, office manager and assistant treasurer, joined the Company in 1930.

The next challenge to 3M's adhesives came when the auto industry marketed all-steel bodies. The original reclaimed rubber-and-resin compounds were satisfactory for fastening upholstery to the steel bodies, but the flammable solvents they contained constituted a fire hazard in welding operations. In 1936, 3M provided the answer in water-dispersed adhesives which also proved their worth in paper and cloth-combining operations. Also developed at this time was a cement for sealing, insulating, and soundproofing auto bodies. These successes have led to the development of other products and such related ones as Underseal rubberized coating for vehicle underbodies.

Adhesives were manufactured in St. Paul until 1936, when factory facilities were acquired in Detroit and all production moved there. 3M began work on synthetic resins to provide raw materials for some of its highly specialized adhesives and coatings which were not available even on special orders from chemical producers. To utilize a large deposit of quartzite at Wausau, research was begun on a process for crushing and artificially coloring the mineral for sale to manufacturers of roofing and asphalt shingles. Perfected in 1932, the process was first in production in 1933 and was further expanded in 1934. These particles are colored with a ceramic enamel, assuring a wide variety of thoroughly standardized, nonfading colors, and a weatherproofing product. Lloyd A. Hatch, with 3M since 1923 as its first chemist, was instrumental in developing this phase of 3M operations and was elected vice-president in charge of the Roofing Granule Division in 1946. During the development of roofing granule processes the Company entered into mineral pigments.

By 1937, 3M encompassed such a variety of fields that at the instigation of Richard P. Carlton, vice-president in charge of manufacturing who had joined the Company in 1921 as laboratory technician, it was decided to create a central research department. Dr. Henry N. Stephens, then of the University of Minnesota and for many years a consultant to the Company, became director of research. In addition to this large central research group, each operating division maintains its own laboratory concerned with developmental problems and quality control of products. The Company also supplies funds to research foundations, universities, and colleges for independent research along specified lines.

Expanding production led naturally to an expansion in the 3M engineering groups and increased production supervision. E. M. Johnson joined in 1928 as chief engineer and was elected vice-president in 1942. Following his death in 1945, C. P. Pesek was made administrator of engineering and in 1947 was elected vice-president. Upon the retirement in 1940 of Charles C. Alliss, general superintendent, Clarence B. Sampair, first associated with the Company in 1927, was appointed production manager and was elected vice-president in charge of production in 1946. Alliss succeeded O. A. Hull, both men having been identified with the very early operations of the Company in Duluth. In 1939 Herbert P. Buetow, an employee since 1926, was made treasurer, replacing the late John Cable, son of one of the Company founders. John L. Connolly, now secretary and general counsel, came to 3M as assistant to the president in 1937, and was elected to his present post in 1939.

World War II brought many new uses for the Company's products and stimulated further research to develop additional military and naval aids. Notably among the products which played important roles are Scotchlite and Safety-Walk, which latter was so very effectively applied to slippery surfaces on aircraft wings, decks of naval vessels, and submarine decks. Scotchlite is a reflective sheeting

made up of thousands of microscopic glass spheres per square inch imbedded in colored transparent plastic backing, which throws light back to its source, yet is invisible to observers anywhere except directly behind the beam. It was used to mark airstrips and as part of emergency equipment on life rafts. This product has been adapted to widely diversified peacetime uses. The most recent product is Scotchlite fabric, in which the reflective sheeting is bonded to a tough, flexible fabric. Vice-president in charge of the division making these reflective products is Bert S. Cross, whose career with 3M began in 1926. His technical work and guidance have been instrumental in the growth of this division, of which he was appointed general manager in 1945.

Among many allied products developed by 3M are cutting, grinding, and finishing compounds, fiber packing and gasket material, sandblast stencil, varnishes and polishes, floor sealers and other compounds, tympan paper trade-marked Spherekote, color pigments, a loose abrasive for finishing fine metal parts called Honite; 3M Silane waterproofing material, and Mistlon, plastic fiber material. Newest product is "Scotch" sound-recording tape, a material which is affected magnetically when passed through a machine, and which records with a fidelity challenging other recording media. Its great durability, convenience, and purity of tone, should rapidly find it a place in American music and commercial fields.

The Company maintains branch offices and warehouses in 16 cities and branch plants in Detroit, Los Angeles, Little Rock, Copley, O., Wausau, Wis., Duluth, Hutchinson, and Fairmont, Minn., and Corona, Calif. It also owns the Mid-States Gummed Paper Co. and Inland Rubber Corp., both of Chicago. A $20,000,000 expansion program is under way (1948) to cover the construction and equipment of a Scotchlite plant and a plant for the manufacture of miscellaneous products at Hastings, Minn., and the expansion of the general factory and office facilities in St. Paul. A former war plant at Bristol, Pa., being equipped for the production of various products, was purchased from the War Assets Administration in 1947. The Company has acquired an outdoor advertising company in Westminster, Md., and three similar organizations on the West Coast for the promotion of Scotchlite signs in outdoor advertising.

Officers of the Company are William L. McKnight, president; Archibald G. Bush and Richard P. Carlton, executive vice-presidents; George H. Halpin, John A. Borden, Bert S. Cross, Joseph C. Duke, Arthur E. Eggert, Lloyd A. Hatch, Ivan C. Lawrence, Cyril P. Pesek, Clarence B. Sampair, and Louis F. Weyand, vice-presidents; John L. Connolly, secretary; Herbert P. Buetow, treasurer; Clarence M. King, assistant secretary and assistant treasurer; and Robert H. Tucker, assistant secretary.

Every year since 1915, stockholders in the Minnesota Mining & Manufacturing Co. have received regular quarterly dividends, yet every year a substantial part of the profits is poured back to finance new research, new factories, new production, as an outstanding record of growth financed through retained earnings. Although the Company has manufactured coated abrasives since 1905, product diversification resulting from research and the attainment of a strong patent position have been major factors in its success.

MONSANTO CHEMICAL COMPANY was founded by the late John Francis Queeny for the manufacture of saccharin, after his initial attempt in 1897 to organize a firm to refine sulfur had failed when fire destroyed the plant on the day it was to begin operation. The Liquid Carbonic Co. was a large user of saccharin, and Queeny approached its founder, Jacob Baur, who lent him $3,500 to put with his $1,500 and agreed to purchase Liquid Carbonic's entire needs from

the new company. The name Monsanto was selected by Queeny to honor his wife, Olga Monsanto. The Company started in a nondescript little wooden building near the St. Louis waterfront. Organization was completed Nov. 30, 1901, and the manufacture of saccharin started Mar. 6, 1902. The personnel consisted of Queeny, a young Swiss chemist, Dr. Louis Veillon, and one assistant.

German manufacturers agreed to supply the intermediate and let Monsanto carry out the refining and finishing operations. After an initial period of losses it appeared the business would show a profit. But the Germans, seeing the threat to their comfortable position in the American market for saccharin as well as other organic chemicals, decided to limit the amount of toluenesulfonamide going to Monsanto. Queeny refused to accept the new terms, and the battle was on. A new source of intermediate was found in Switzerland. Then the Germans moved in and put up their own saccharin plant in New Jersey. They cut prices, sometimes holding the market down to half the cost of production. From $6 a pound before Monsanto entered the field, the price dropped to 60¢. For three years it appeared to be a losing fight.

During this period John F. Queeny made a trip to Germany to look into the possibilities of producing vanillin. He asked his friend, Ralph Wright, recently returned from studying in Germany, to recommend an interpreter. Wright suggested his former roommate, a young Swiss student, Gaston DuBois. So well did Queeny and DuBois get on that upon his return Queeny invited DuBois to come to America and build a vanillin plant. DuBois arrived with his own platinum crucible, weights, hydrometers, and other miscellaneous equipment. "It is surprising how inaccurate our thermometers were," he related after becoming vice-president. "Frequently they were 10 or 15 degrees off at 250 degrees. Having no standard, I found it necessary to provide one, so I used to go to the St. Louis School of Pharmacy and borrow a thermometer. We borrowed almost everything, even wrenches and chain hoists, but we got along pretty well. After saving a dollar or two we bought wrenches."

From 1901-5 Monsanto was constantly on the edge of bankruptcy. In 1905, however, improved methods of manufacture enabled it to meet at a profit—$10,600—the lowest prices its foreign competitors were willing to make: The German stranglehold was broken. By sale of stock capitalization was increased from the initial $5,000 to $20,000. In 1906 the handful of patient investors saw their first cash dividend of 10%. All this time John Queeny had been operating his infant company while holding a more secure position with a drug distributor. By 1907 he felt safe in resigning to devote all his time to Monsanto.

Meantime new products were added to the Company's line. Gross sales for 1905 were $111,643, consisting essentially of saccharin, caffeine, vanillin, and iron by hydrogen. Other fine chemicals added shortly included Phenacetin, glycerophosphates, chloral hydrate, phenolphthalein, acetanilide, and coumarin. By 1914 Monsanto was a going concern. Like others, however, it was still dependent on Europe, especially Germany and Switzerland. Almost all of its products were manufactured from imported intermediates; a large part of the chlorine used was coming from abroad; all glassware and most plant equipment and measuring instruments were German.

At the outbreak of World War I Monsanto found its supply of intermediates cut off. Only a very small stock of Phenacetin was on hand. This drug was then being used extensively in influenza and it became necessary for Monsanto to learn how to make it from the ground up, whereas previously it had been made from German *p*-phenetidine by simple acetylation. Numerous other war-created problems had to be met, intermediates had to be supplied, and, in many instances, new

processes had to be developed, one of the best examples of this being the manufacture of phthalic anhydride for phenolphthalein.

With the Company in the intermediate as well as the fine chemical business, there arose a greater need for such basic chemicals as caustic soda and chlorosulfonic, sulfuric, muriatic, and nitric acids. All were being purchased from the Commercial Acid Co. near East St. Louis, just across the Mississippi from Monsanto. The Commercial Acid plant was in rather poor condition, but its location looked promising to Queeny as a spot for expansion. Consequently, in 1917, Monsanto made its first move in lateral growth by acquiring this plant, which has since then developed into one of its largest operations. Heavy chemicals such as mineral acids, chlorine, salt cake, niter cake, and caustic soda still predominate in volume among its nearly 100 different products which include various organic intermediates plus a few recently added phosphorus derivatives. The plant is located in the incorporated village of Monsanto, Ill.

In 1920 a half-interest was purchased in the Graesser Chemical Co. of Ruabon, North Wales. This house, established in 1867, was the world's largest distiller of natural phenol and a manufacturer of pure pyridine and other coal-tar products. Now wholly owned by Monsanto and operating under the name of Monsanto Chemicals, Ltd., it also manufactures rubber chemicals, phthalic anhydride, benzoic acid, saccharin, vanillin, aspirin, and other Monsanto products at Ruabon and Sunderland, England. It supplies a considerable portion of the British Empire and normal Continental trade.

Following World War I, Monsanto set out to build up and strengthen its product structure. Where the original procedure had been to select a finished product and build downward through the intermediates and finally to the basic materials, the new growth took place in all directions—up, down, laterally. Chlorine manufacture, established in 1920, led to chlorobenzene, and this in turn served as the intermediate for many products including *p*-nitroaniline, synthetic vanillin, ethyl vanillin, and dinitrochlorobenzene. Waste hydrogen from the chlorine cells was utilized to make cyclohexylamine and many other products. Likewise, the phenol group grew. Chlorinated phenols were developed to the extent that it was necessary to increase chlorine production, which reduced the cost of chlorine, thus aiding many of the other Monsanto products. Today, the over-all Monsanto product structure is comprised of many such interlocking family groupings.

In 1928 John F. Queeny was 69 and feeling it was time to turn the leadership of the Company over to younger hands, he chose his son, Edgar Monsanto Queeny, then 31, as his successor. He retained the chairmanship of the board, however, until his death in 1933. Under Edgar Queeny's direction, Monsanto Chemical Co. grew from a $12,000,000 organization in 1928 to one with assets of more than $100,000,000 in 1946. Its personnel rose from 2,130 in 1930 to 4,054 in 1935, 7,284 in 1940, 12,658 in 1945.

The expansion program instituted by Edgar Queeny began with the purchase of three well-established concerns in 1929: the Rubber Service Laboratories of Akron, O., and Nitro, W. Va.; the Commonwealth Division of Mathieson Alkali Works, Newark, N. Y.; and the Merrimac Chemical Co. of Boston, one of the largest and oldest chemical manufacturers in New England.

Rubber Service Laboratories, though only seven years old and not very large, by 1929 had achieved a commanding position in rubber chemicals, mainly through its pioneering of the technical service method of selling its products. As the Rubber Service Department of Monsanto, it maintains a completely equipped service laboratory in Akron, where customer plant problems are solved and rubber stocks developed to meet various requirements. Most of the close to 100 items are

made at the Nitro plant and include a wide variety of antioxidants, accelerators, softeners, and other rubber-compounding materials of coal-tar origin. Today, Monsanto's production of rubber chemicals is three times that of Rubber Service in 1928.

The Commonwealth Division of Mathieson in 1929 was the largest American producer of benzoates, benzoic acid, benzaldehyde, benzyl alcohol, and benzoyl chloride used in the food, perfume, and dyestuff industries. It also manufactured coumarin and vanillin, already on the Monsanto list. All these products found a place waiting for them in the master-product structure.

The largest of the three additions, Merrimac, with plants at Everett and Woburn, Mass., was controlled by a Boston management firm. It was earning money—about $470,000 in 1928—had a staff of well-trained men, and was making heavy and special chemicals closely paralleling Monsanto's. Monsanto had always been handicapped in serving Eastern markets because it had no manufacturing facilities in the East. The Merrimac setup was as close to what Monsanto could hope for without building it, itself. It purchased the company outright with capital stock valued at $4,500,000. The Woburn plant was scrapped and rebuilt at Everett. Merrimac's president, Charles Belknap, was transferred to St. Louis where he became executive vice-president in 1935, president in 1943, and from 1939 until a year after his retirement in 1945, chairman of the executive committee.

Merrimac exists today as one of the four divisions of Monsanto, its operations becoming less and less confined to the requirements of the East, although it continues as the main Monsanto point of supply for this market. Gradually, however, it has built up its own interrelated product structure which, in turn, has become intimately woven into the central framework of the Company. Manufacturing facilities for many of the organic products made at St. Louis have been duplicated at Everett.

An offshoot of this acquisition was the formation of the New England Alcohol Co. in 1933, to insure a continuous and dependable supply of ethyl alcohol for many of Merrimac's processes. Ownership was divided between Monsanto and Central Aguirre Associates, with the sugar company supplying the molasses, and Monsanto holding a 55% interest and carrying out operation and marketing. In 1932 Monsanto (Canada) Ltd. was formed, more effectively to handle sales problems in Canada.

In 1933 Theodore Swann, founder and president of Swann Corp. of Birmingham, Ala., offered Monsanto a controlling interest in the company which had phosphate plants in Anniston, Ala., and Carondelet, Mo., and a subsidiary, Wilckes, Martin, Wilckes, in Camden, N. J., making lampblack. A policy of retrenchment and increasing efficiency put into effect at Monsanto's suggestion resulted in tidy profits in 1934-35. The opportunity looked good to Monsanto to buy a ready-made position in the phosphate field which would tie in well as a raw material source for Monsanto's organic phosphates and phosphorus chloride and oxychloride. So, in 1935 Monsanto traded about $8,000,000 of its common stock for 100% ownership of Swann Corp.

Immediate steps were taken toward securing the Company's position in this field. An outstanding research and engineering achievement of 1936 was an improved large-scale method for electric-furnace production of elemental phosphorus. Phosphate-bearing tracts in Tennessee, just south of Nashville, were purchased and a $3,000,000 plant was erected near Columbia, at Monsanto, Tenn. This work received the *Chemical & Metallurgical Engineering* award for chemical engineering achievement in 1937. Beginning that year, daily tankcar shipments of

pure yellow phosphorus were made from Tennessee to Anniston, Ala., Monsanto, Ill., and later to the Trenton, Mich., plants.

In 1936 Monsanto acquired the facilities of a comprehensive research laboratory and the services of research chemists and physicists, two of them of international note. Drs. Charles A. Thomas and Carroll A. Hochwalt had organized a research laboratory of their own in 1926 after several years' research with General Motors. After having placed an increasing number of studies with the Thomas & Hochwalt Laboratories, Monsanto bought the firm and renamed it Central Research Laboratories. Its assignment has been to carry on long-range and fundamental scientific studies for the Company. In 1942 Dr. Thomas was named director of Monsanto and in 1945 was elected vice-president and member of the executive committee. Dr. Hochwalt, who had served with Dr. Thomas as codirector of Central Research Laboratories, was named its director.

Monsanto entered the plastics field in 1938 with the purchase of the Fiberloid Corp. of Springfield, Mass. For many years it had been supplying nitrating acid for nitrocellulose and phenol for phenol-formaldehyde; more recently it had established itself in the specialized plasticizers field. Fiberloid, one of the oldest and largest producers of cellulose acetate, cellulose nitrate, and other plastics, had long been a good Monsanto customer. When one of Fiberloid's largest stockholders died in 1933, Monsanto was invited to buy the stock from the estate. The purchase was made and the investment proved profitable, with the result that a transaction was completed in 1938 which gave Monsanto all the assets of Fiberloid in return for Monsanto common stock. Fiberloid became the Plastics Division of Monsanto. Among its assets was a 50% interest in Shawinigan Resins Corp., the other 50% being held by Shawinigan Chemicals Ltd. of Canada. The Shawinigan Resins plant, located adjacent to the Monsanto plant at Springfield, produces polyvinyl acetals which are fabricated in continuous sheet form by Monsanto proper.

To broaden its plastics line still further, Monsanto purchased in 1939 from the Corn Products Refining Co. and the Commercial Solvents Corp. the assets of the Resinox Corp., at that time the third largest producer of the big-volume phenolic molding compounds. With transfer of the Resinox operations from Edgewater, N. J., to a newly constructed plant in Monsanto's Springfield group, these plants became the largest plastics manufacturing operation in one location in the United States. Resinox added phenol-formaldehyde molding materials and resins to the Monsanto line, which already included cellulose acetate, cast phenol-formaldehyde, cellulose nitrate, vinyls, and polystyrene.

First to be affected by World War II were the employees of Monsanto Chemicals, Ltd., at Ruabon, Wales, and Sunderland, England. Dr. Lloyd F. Nickell, managing director, ordered the offices moved from London to the plant works. In 1940 Monsanto and Nicholas Pty., Ltd., jointly erected a plant in Australia for the manufacture of aspirin, methyl salicylate, phenol, and other pharmaceuticals important to the war effort. By 1942 nearly 100% of the Company's output was going into war and essential civilian use.

At the outset of the war Monsanto announced it would operate its government projects at cost. Thus, when it completed the Chemical Warfare Service plant at Monsanto, Ill., it turned back to the Government that part of its fee over and above the actual cost of construction supervision. Other projects operated for the Government included a TNT plant at Karnack, Tex., and a styrene plant at Texas City, Tex. The latter produced about 21% of the styrene needed for the synthetic rubber program and was purchased from the Government for $9,550,000 in Aug. 1946.

The most significant of Monsanto's wartime contributions was its part in the development of atomic energy. Units of the Central Research Laboratories were engaged in research on plutonium and Monsanto for some time operated the Clinton Laboratories at Oak Ridge, Tenn. All phases of this work were under Dr. Thomas, who was later awarded the Medal of Merit. On July 1, 1945, Monsanto took over the operation of Clinton Laboratories under contract to the Manhattan Engineering District. A large-scale research program in the peacetime distribution of radioactive isotopes was made and the use of atomic energy for the generation of electric power. That year the Company supervised a $2,500,000 extension at Clinton.

Monsanto constructed a plant at Trenton, Mich., in 1942 for its Phosphate Division, and another in Bahia, Brazil, in 1944, to provide a dependable source of supply for its special organic intermediates. In 1944 it acquired as a wholly owned subsidiary, I. F. Laucks, Inc., of Seattle, manufacturers of plywood adhesives, with plants at Los Angeles, Portsmouth, Va., Seattle, Lockport, N. Y., Stanbridge, Que., and Vancouver, B.C.

Stockholders of the Company in 1946 elected Edgar M. Queeny chairman of the board, Charles Belknap chairman of the executive committee, and William M. Rand president. In Mar. 1946 the board announced an expansion program to cost more than $50,000,000 in the next two years, which would include 130 construction and expansion projects.

The development program of the 1930's. the Company's internal growth, together with wartime responsibilities converted to peacetime use, have contributed to the Monsanto of today. Total products now number in the hundreds, and their production is made possible by an army of chemists, engineers, technicians, and workmen. In the divisional laboratories and the Central Research Laboratories in Dayton, continuous investigation is being carried on. Monsanto plants reach from headquarters in St. Louis eastward to Sunderland, England, westward to Melbourne, Australia, north to Canada, and south to Brazil. They serve markets which are world-wide. They serve industry which serves mankind.

MUTUAL CHEMICAL COMPANY OF AMERICA makes and develops chromium chemicals. This branch of the chemical industry in the United States dates back to 1827, when Isaac Tyson of Baltimore chanced upon some lumps of chromite. He traced the specimens to their source, acquired the properties, and developed the important Reed and Wood Mines, the former in the vicinity of Baltimore, and the latter near the Pennsylvania-Maryland state line. The ore was exported to the works of John and James White in Glasgow, then principal producers of bichromate of potash for the paint and dye industry.

Tyson soon realized that exhaustion of his mines and the recent discovery of important deposits in Asia Minor would interfere seriously with his ore sales, so in 1845 he established the Baltimore Chrome Works to manufacture potassium bichromate. He successfully conducted the business until his death in 1861, after which his son, Jesse Tyson, took over.

Then other chemical manufacturers became attracted to the bichromate field. In 1882 Henry Bower, a pioneer chemical manufacturer, joined with Henry Pemberton and Harrison Bros. & Co., likewise of Philadelphia, in organizing the Kalion Chemical Co. to manufacture bichromate of potash. The plant was located on Gray's Ferry Road, adjoining those of the Bower Chemical Mfg. Co. Later, bichromate of soda was produced and in 1902 Kalion purchased its competitor, the Baltimore Chrome Works. In 1904 production at the Philadelphia plant was discontinued and the entire chromium chemical business of the Bower Co. trans-

ferred to Baltimore in 1906. That year Bower purchased the Kalion Co. and surrendered its charter. Bower Co.'s officers at that time were George R. Bower, president; William H. Bower, 1st vice-president; Frank B. Bower, 2d vice-president; Sydney Thayer, secretary-treasurer.

Another competitor appeared when the Mutual Chemical Co. of Jersey City, incorporated in 1895, began making bichromate of potash experimentally in 1897. Its organizers were Edward Loeb of Philadelphia, Albert Goldman, William S. Gray, and Max Marx, all prominent in the chemical industry. At the outset the company manufactured only prussiate of potash, but soon diversified its products. William R. Peters became interested in the company soon after its organization, as did also Peters, White & Co.; Herbert M. Kaufmann became plant superintendent in 1896 and undertook the production of bichromate of soda.

The American Chrome Co. was the outgrowth of the attempt of Robert H. Forderer, pioneer in chromium tannage, to produce his own bichromate. The well-known leather firm of Lucius Beebe & Sons of Boston was associated with him in the enterprise. After a short period, the manufacture of bichromate was transferred to Arlington, Mass., and Junius Beebe supplanted his brother Marcus Beebe as manager. Actual operations were directed by a Mr. Wood and Horace Adams.

In Oct. 1908 the principal owners of the above three companies, recognizing the economies which would result from large-scale centralized production, decided to consolidate their interests. A new company, the present Mutual Chemical Co. of America, was incorporated and acquired the business of its three predecessors. The officers were: Frederick W. White, president; George R. Bower, 1st vice-president; Sumner W. White, treasurer; Richard P. Chillas, secretary; Herbert M. Kaufmann, general manager. The first board of directors were: George R. Bower, William H. Bower, Junius Beebe, Albert Goldman, Herbert M. Kaufmann, William R. Peters, Frederick W. White. Capitalization consisted of 20,000 shares of preferred and 20,000 shares of common stock of $100 par value each. Although the preferred stock was noncallable, most of it has since been purchased and retired. There remain outstanding 4,209 shares of preferred and 123,743 shares of no-par common. Originally good will was valued at about $2,500,000; its present book value stands at $1.

It is estimated that the production and consumption of bichromates in 1908 were approximately 30,000,000 lb. per annum each. Chromium compounds were used largely in the tanning, dry color, and textile industries. Later their use in treating copper and its alloys developed important outlets and other less well-known uses arose, but the total requirements increased only moderately. In the first 20 years of the Company's existence, total consumption barely doubled the 1908 figure. In the second half of the 1920's, the increasing use of chromic acid in chrome plating greatly enlarged the demand for bichromate of soda. By 1941 production was 166,830,000 lb. Today, Mutual continues to be the world's largest producer of chrome chemicals, but it does not enjoy as large a percentage of the total business as in 1908.

Following the Company's organization, production at Arlington was discontinued in 1909, the Baltimore plant, the largest unit, was temporarily altered, and plans were made to enlarge the Jersey City plant and produce the entire requirements there. However, the one-plant plan was later abandoned and instead the Baltimore works was radically revamped by early 1915, barely in time to meet the heavily increased demand for bichromate production during World War I. The Company's foreign business, which prior to 1914 had been confined largely to Japan, was extended to other countries. After the war, Mutual bichromates re-

tained an important competitive position in Europe, India, and South America, so it became necessary in 1920 to provide additional facilities at Baltimore.

Much experimental chemical engineering work has been undertaken by Mutual: varying production methods, sundry types of furnaces, recovery of alumina from chromite, modified leaching processes, and other subjects. To improve yields and eliminate manual labor in sodium bichromate manufacture, attention was devoted to the development of a mechanical furnace to replace the older, reverberatory type. By modifying the oxidation process, rotary kilns were successfully used for this purpose. This was largely the work of Omar F. Tarr, who came to the Company as chemical engineer in 1920.

Another interesting development was the manufacture of chromic acid from bichromate of soda, begun in 1927 under the direction of Harry Heller, who joined the Company as chemical engineer at Jersey City, in 1914. Heller also engineered production of a one-bath tanning compound, Koreon, whose principal constituent is basic chromium sulfate. Tarr introduced the use of carbon dioxide for converting chromate of soda into bichromate, which greatly reduced the quantity of sulfuric acid required. Most of the Company's engineering and development work has been under the supervision of Tarr, now vice-president and technical director, and Heller, vice-president in charge of engineering.

During the depression, the Jersey City plant was shut down for some months and production of bichromate of potash, Koreon, and chromic acid was moved to Baltimore. Heller was transferred to Baltimore and the management at Jersey City was assigned to Herbert J. Kaufmann, chemical engineer with the Company since 1927. The chamber acid plant of about 60 tons daily capacity erected at Jersey City early in 1917 proved impractical after a few years' competition. It was shut down in 1932 and scrapped in 1946. In addition to bichromates of soda and potash, and oxalic acid, Mutual makes neutral chromates of soda and potash, ammonium bichromate, chromic acid, Koreon, and by-product sodium sulfate for the kraft pulp industry.

From its incorporation to Sept. 1933, the Company continued under Frederick W. White as president and Herbert M. Kaufmann as general manager. Then White resigned to become chairman of the board and Dr. Kaufmann succeeded him as president. At the same time, George A. Benington, formerly with American Agricultural Chemical Co., became vice-president in charge of sales. He succeeded to the presidency, July 1, 1943, when Dr. Kaufmann resigned to become chairman of the board.

For many years the Company's research was confined almost entirely to processes, but more recently it has been expanded to cover uses. In 1936 a chromium fellowship was established at the Mellon Institute under Marc Darrin, who after a few years came to Baltimore as assistant director of research. The Research Laboratory has devoted much time to corrosion problems, chromates as corrosion preventives, and chromic acid in anodizing and in the coloring of metal surfaces. A fellowship was established at Lehigh in 1937, under Dr. Edwin R. Theis, for research connected with the use of chromium salts for tanning. In Nov. 1944 this work was superseded by a broader program, sponsored by the bichromate industry, also under Dr. Theis' direction.

As no important deposits of better-grade chrome ore are available in the United States, maintenance of an adequate supply has always been paramount for Mutual. About 1916 the Company acquired a chrome ore property at Caribou Lake in Quebec. The low-grade ore mined stood Mutual in good stead during World War I, but the concentration cost was high, so operations were discontinued after 1920 and the plant dismantled and abandoned. The mine was leased

to the Canadian Government in World War II and a new concentrating plant erected. This has also been abandoned.

Active development of recently acquired New Caledonia deposits surveyed by W. Spencer Hutchinson, professor of mining at M.I.T., did not begin until 1924 when Enoch Perkins, mining engineer, was engaged to represent Mutual there. Under his management the Fantoche and Alpha Mines yielded worthwhile quantities of excellent ore until 1945. Perkins had charge of Company ore operations since 1933, when his headquarters were shifted to New York. He is one of the three vice-presidents.

In 1925 the Vanadium Corp. of America and Mutual joined in purchasing ore property in Rhodesia and limited operations were undertaken. A good grade of ore was produced but financially the results were not attractive and the deposits were held for some years as a reserve. During World War II the property was leased to local miners and in 1944 Mutual sold its interest to Vanadium. Owing to extensive Transvaal deposits now being actively mined by independent interests, an adequate chrome ore supply for the chemical industry seems assured.

The demand for bichromates increased greatly prior to and following the beginning of the war in 1939. Capacity of the Jersey City plant was doubled and the Baltimore works considerably expanded both for the production of bichromate and chromic acid. The demands for military purposes, however, exceeded the available supplies and the Mutual Chemical Co. was given a contract by the War Production Board to build new facilities at Lake Charles, La., with R.F.C. funds. This was, however, canceled immediately following the end of the war and the project abandoned. With the return of peace, the demands for chromium chemicals, due to new and increased uses, still exceed the available supplies and the Company has undertaken the construction of a new bichromate plant, on property adjoining its Baltimore plant, which is scheduled for completion by the end of 1949.

At present, much of Mutual's stock is held by the families of the original owners. Sumner W. White, Jr., secretary and assistant treasurer, who joined the Company in 1925, is the son of Mutual's first treasurer. William J. Mackay has been treasurer since 1936. The present board of directors consists of: George A. Benington, Marcus Beebe, Henry Bower, Harry Heller, Herbert M. Kaufmann, Thomas M. Peters, Omar F. Tarr, Sidney Thayer, Jr., George E. Warren, and Sumner W. White, Jr.

NATIONAL ALUMINATE CORPORATION was a merger of two earlier companies that had their beginning as a result of experiments in water treatment made by two World War I veterans: Lt. H. A. Kern and Lt. Col. P. Wilson Evans.

Kern talked with his friend, Dr. Frederick Salathe, a Standard Oil Co. chemist who had discovered a water-treating compound, and another meeting in 1920 between them resulted in the formation of the Chicago Chemical Co. Arrangements were made with Pennsylvania Oil Co. to make and drum the new company's product, Colline, in its plant at Randolph and Green Sts. in Chicago. Aside from his financial interest, Dr. Salathe was not concerned with the operation, so to Kern and a secretary went the task of marketing Colline. Within two years the sales had expanded to the point where Pennsylvania Oil could not make and drum sufficient product to meet the demands. In 1922 a building at 420 N. Western Ave. was leased and became the first plant and office building of the Chicago Chemical Co. Distribution was extended beyond the Chicago area and salesmen introduced the product to power plant engineers in Wisconsin, Indiana, and others parts of Illinois.

Though almost fatal, this move brought to light the very important fact that a successful water treatment system could be developed only through a scientific approach to the problem and a program of continuing research. Colline—so successful in Chicago—was far from satisfactory in other localities. Research was started to discover the reason. Kern found that sodium aluminate answered the boiler water problems better than Colline. An 8% solution made its appearance in the water-treating field as Kern's Water Softener or KWS sodium aluminate.

About the same time Evans, then assistant chief engineer for Armour & Co., was discovering the value of sodium aluminate in another phase of water treating. He had used it successfully two years previously as an internal boiler water treatment. Finding it extremely valuable in speeding up the reaction of lime-soda softeners, he obtained patents covering the process. To market it for this purpose, the Aluminate Sales Corp. was formed in 1922 and a liquid sodium aluminate made and drummed in an old warehouse in the Chicago stockyards. Evans' No. 2 liquid sodium aluminate is still being made and widely used.

Evans developed a method for sampling water from the boiler as well as from feed lines, and established a basis for control. Sales were directed almost exclusively to railroads, who are large users of lime-soda softening plants, and the sodium aluminate was so well received that the company was soon ready for expansion. In 1922 Kern sought out Evans to purchase his company's requirements of sodium aluminate for water-treating purposes, which he did for five years. Both companies continued to grow with relatively little conflict, since Chicago Chemical concentrated on sales to stationary industrial power plants, while Aluminate Sales sold almost exclusively to railroads. In July 1925 the Chicago Chemical Co. moved to its own new building at 6216 W. 66th Place in the Clearing Industrial District of Chicago. When two years later a new and improved liquid sodium aluminate was developed, an agreement between Chicago Chemical and Aluminate Sales was arranged whereby the products of both concerns would be manufactured in the former's Clearing plant.

Meanwhile the Aluminum Co. of America had obtained several patents on dry sodium aluminate, which it began to sell to municipalities. In 1928 it merged its aluminate interests with the two other producers whose aims and policies were also based on the concept that laboratory study and research, as well as field control and supervision through a field service staff, are necessary phases of a thorough method of water treating. National Aluminate Corp., or Nalco, succeeded Chicago Chemical Co. and Aluminate Sales Corp., and, in exchange for 27.5% of its capital stock, it received from the Aluminum Co. of America certain patents and municipal water-treating accounts. The original board of directors comprised Arthur Meeker and C. J. Faulkner of Armour & Co., C. B. Fox and J. F. Linthicum of the Aluminum Co., and H. A. Kern, president, and P. W. Evans, vice-president of the Corporation. The other officers were H. J. Young, secretary-treasurer, and Miss M. A. Spinner, assistant secretary-treasurer.

In 1929 the Corporation established the Visco Products Co., Inc., to develop and promote crude oil emulsion breakers and chemical compounds for conditioning mud used in drilling oil wells. This almost wholly owned subsidiary, which began production in a very small shack, today occupies offices in Houston and a modern laboratory and plant at Sugarland, Tex. The second acquisition, in 1930, was of the Paige-Jones Chemical Co. of New York, with valuable railroad accounts and equipment and rights for fabricating water-treating chemicals in the more convenient ball-briquette form. With the increasing demand for Nalco water-treating chemicals, approximately one-third more factory space had to be added in 1933.

National Aluminate ventured into the foreign field in 1932, when in conjunction

with Aluminum, Ltd., it established Alfloc, Ltd., in London. In 1934 Nalco bought out Aluminum, Ltd., and resold 51% of the Alfloc stock to Imperial Chemical Industries, Ltd., which in 1939 bought the remaining interest in Alfloc. In 1935 Nalco began production of zeolite by a drying process at LaGrange Park, Ill. Although slow to start, zeolite has become an important business and is in ever-increasing demand.

The Corporation's greatest expansion year was 1937. The size of the home office and Chicago plant was almost doubled by the purchase and construction of additional manufacturing facilities and the erection of a new and ultramodern office and laboratory building. Two new vice-presidents were appointed to newly created positions: Frank H. Thorne, who had joined the Chicago Chemical Co. in 1924 as Cleveland salesman and later became sales manager of Nalco and president of Visco Products Co., became vice-president in charge of the Industrial Department. Clarence B. Flint, who came to Nalco with the Paige-Jones Chemical Co., was the other new vice-president, while Evans became senior vice-president.

Also in 1937, in conjunction with Canadian Industries, Ltd., Aluminate Chemicals, Ltd., was established in Montreal, Canada, with a Nalco license to manufacture water-treating chemicals in Toronto. Canadian Industries still holds 51% of the stock and Nalco 49% in this active concern.

From 1937 on, Nalco's scale of operations continued to increase to the point where additional manufacturing space was required in 1939, and again in 1940, 1941, and 1944. During the war the Corporation's production was maintained at a maximum level. The Chicago Chemical Co., inactive since 1928, at the request of the Government in 1942 leased a plant in Chicago built under its supervision by the Defense Plant Corp., to produce catalyst for high-octane aviation gasoline. This plant began production in 1943 and operated at maximum capacity until the end of the war, when Chicago Chemical purchased it from the War Assets Corp. In July 1946 the Chicago Chemical Co. was dissolved and its properties at 71st St. and Pulaski Road began operating as a division of the Corporation, producing both catalyst and zeolite at full capacity.

With this purchase and the erection of new additions to the Corporation's office, laboratory, and production facilities, 1946 has been another outstanding year in the development of Nalco and has kept it abreast of the rapid postwar progress of the chemical industry. From its very simple beginning with one or two formulas of sodium aluminate, National Aluminate Corp. has today reached the point where it regularly makes 181 chemicals, more than 150 of them for specific water treatment problems. Only through a substantial investment in time and facilities for research could this development have been possible.

NATIONAL ANILINE DIVISION, Allied Chemical & Dye Corp., prior to merger as a division in 1941, was the National Aniline & Chemical Co., Inc. Organized in New York, May 26, 1917, National Aniline brought together the Schoellkopf Aniline & Chemical Works of Buffalo, the W. Beckers Aniline & Chemical Works of Brooklyn, the Benzol Products Co. of Marcus Hook, Pa., and a year later, the Century Colors Corp. of Nutley, N. J. Included also were certain facilities of the Semet-Solvay Co., the Barrett Co., and the General Chemical Co. previously applied to the manufacture of special coal-tar intermediates. The new company represented the first completely integrated, domestic company for production from coal-tar crudes, through all intermediate stages, to a full line of dyes.

Oldest and largest of the constituent companies was Schoellkopf which had operated continuously since 1879. At the outbreak of the First World War, Schoellkopf was manufacturing approximately 100 coal-tar dyes representing about

10% of domestic consumption. These were chiefly of the azo type, comprising acid, direct, chrome, and a few oil colors, together with a limited number of food colors, basic colors, and nigrosines, all manufactured from intermediates imported from Germany. Earlier attempts to manufacture aniline and various naphthalene intermediates had been abandoned principally because of German competition. After the start of World War I, prompt and vigorous action was taken to establish domestic manufacture of the previously imported, but now unavailable intermediates. Using nitrobenzene and aniline already in production at Benzol Products, Schoellkopf began manufacture of benzidine in 1914, and of *p*-aminoacetanilide, *p*-nitroaniline, dinitrobenzene, *m*-phenylenediamine, and sulfanilic acid in 1915. Also in 1915, such critical naphthalene derivatives as *β*-naphthol, H acid, chromotrope acid and, from Solvay Process Co. chlorobenzene, dinitrochlorobenzene for sulfur blacks, were made.

By 1916 nitro and amino derivatives of toluene were available from Benzol Products and *α*-naphthylamine from Barrett. Additional naphthalene derivatives were in production at Buffalo, including Schaeffer salt, R salt, G salt, 1,5- and 1,8-naphthylamine acids, phenylperi acid, naphthionic acid, and Neville-Winther's acid, and such important benzene and toluene derivatives as aminoazobenzene, aminoazotoluene, diazosalicylic acid, and *p*-nitrotoluenesulfonic acid. At the time of the merger Schoellkopf had built back the number of its offerings nearly to the prewar figure, although the newly developed line was not identical with the old. Schoellkopf had concentrated on azo colors and related intermediates, but by 1917 its production of nigrosines had been increased and processes established for sulfur blacks, the safranines, methyl violet, and methylene blue.

Beckers, founded in 1912, was manufacturing 15 dyes at the outbreak of war. Its production decreased as stocks of imported intermediates were exhausted, then increased as domestic intermediates became available. It became a large producer of gallocyanine, a mordant blue of the anthraquinone type, which led to the manufacture of other anthraquinone colors, including the first domestic manufacture of acid alizarin blues (alizarin sapphires). Beckers had been one of the first to manufacture dimethylaniline, and methyl violet and methylene blue from it. Interest in this type of substituted aniline resulted in 1916 in the first domestic manufacture by Beckers of ethylaniline, ethylbenzylaniline, and ethylbenzylanilinesulfonic acid, and of various acid triphenylmethane colors therefrom. Certain azo colors principally of the acid and chrome type were also produced. Sulfur colors were added early in 1917 by purchase of the Standard Aniline Products, Wappingers Falls, N. Y., a substantial producer of sulfur black.

Benzol Products had been established by Barrett, General Chemical and Semet-Solvay to manufacture nitrobenzene and aniline. Operating on a limited scale in 1914, its primary problem was huge, rapid expansion. In 1916 operations were diversified by production of *o*- and *p*-nitrotoluene and the corresponding toluidines. At the time of the merger, Benzol Products was the largest domestic producer of the nitro and amino derivatives of benzene and toluene.

Upon its organization in 1917, National Aniline & Chemical thus possessed facilities for processing benzene, toluene, and naphthalene through to well over 100 finished dyes of such application classes as acid, basic, chrome, direct, sulfur, and oil colors, and embracing such varied chemical classes as azo, pyrazolone, triphenylmethane, azine, thiazine, alizarin, and sulfur dyes. Thereafter steady progress continued in the development of new and more complex intermediates and from them a steadily widening line of additional colors of improved fastness and application properties. In 1917 processes were established for metanilic acid, the intermediate required for several fast acid blues and blacks and the acid yellow,

metanil yellow; picramic acid, basic intermediate for a line of chrome colors; *p*-nitrotoluenesulfonic acid for the stilbene yellows and oranges; tolidine for direct colors, including benzopurpine; 1,2,4-acid for chrome blues and blacks; gamma acid for direct and developed blacks for cotton; and primuline base for the cotton dye, primuline. In 1918 manufacture was begun of Cleve's acid for direct blues and blacks; chloro H acid for diamine rose; anthraquinone and anthrarufin for the alizarin sapphire line of fast acid blues; and tetramethyl-diamino-diphenylmethane for auramine. Manufacture of synthetic indigo was also begun this year.

In 1919 manufacture of a new naphthalene derivative, I acid, made possible an entirely new series of direct blues for cotton; manufacture of *o*-aminophenol-*p*-sulfonic acid gave rise to new series of chrome colors; manufacture of diaminostilbenedisulfonic acid permitted production of new series of direct yellows, oranges, and browns, and various substituted benzaldehydes. An important step was taken in 1920, when National worked out the constitution of the developed black, Zambesi black D, which was a closely guarded German trade secret. The dye required a new intermediate, aminocresol methyl ether, which previously had not been made in the United States or even imported. Manufacture of both intermediate and dye was established.

Early in 1921 National Aniline was consolidated through stock ownership with four other companies to form Allied Chemical & Dye Corp. During the earlier 1920's all manufacturing was concentrated at Buffalo and much attention was given to the improvement of processes hastily improvised under the urge of wartime and immediate postwar necessity. Much significant work was accomplished in improving the finished dyes as to purity and better application properties. New products were not neglected, however, and new intermediates made possible the production of new dyestuffs, usually of greater complexity, improved fastness, and better adapted to specialized application. In 1921 the further elaboration of I acid by condensation with phosgene into the new intermediate I acid urea made possible a new line of cotton oranges, reds, and scarlets of improved fastness. A new chemical type of acid color was first manufactured, quinoline yellow.

The years 1922-23 marked the initiation at Buffalo of full-scale commercial processes for the vapor phase catalytic oxidation of aromatic hydrocarbons. First installed was production of phthalic anhydride by oxidation of naphthalene. This new process had been developed commercially by Barrett and was destined to replace on a world-wide scale the former process of oxidation of naphthalene by fuming sulfuric acid, developed by the Germans as the primary step in the synthesis of indigo. National's first interest in phthalic anhydride was for the production of anthraquinone for vat and alizarin colors. This process for anthraquinone, which National also established in 1922, completely replaced in the United States the earlier and then-current process based on the oxidation of anthracene as practiced in Germany and Great Britain. In 1923 commercial facilities were installed for the catalytic oxidation of benzene to maleic acid, a reaction worked out by Barrett, patented in 1919, and subsequently developed on pilot-plant scale. The maleic acid was produced solely for conversion by high-pressure reaction with water to malic acid, a food acid and general acidulant similar in its uses to the natural citric and tartaric acids. Manufacture of the intermediate α-naphthylamine was transferred from Barrett to National in 1926.

In 1927 National began to build seriously upon a vast amount of earlier research work directed to the production of vat dyes. The first step had to be taken with the manufacture of phthalic anhydride and anthraquinone in 1922. This technology was now extended to the manufacture of chloroanthraquinone, from phthalic anhydride and chlorobenzene, and then of β-aminoanthraquinone, a fun-

damental vat dye intermediate. In 1928 National announced and introduced its initial line of six important vat dyes.

The years 1929-30 marked the beginning of National's expansion into fields other than dyestuffs. Even prior to World War I, research laboratories, particularly that of General Electric Co., were investigating resinous products obtained by condensation of phthalic anhydride with glycerin. These resins were originally suitable only for casting purposes and commercial development lagged. In Jan. 1927, General Electric had filed a patent application (issued in 1933 and declared invalid in 1936) on a modified type of resin in which a portion of the phthalic anhydride was substituted by drying-oil fatty acids. Such resins were soluble in paint and varnish vehicles and air-dried readily to tough films, thus being suitable for use in coating compositions. In 1929 manufacture of this new type of resin began in earnest coincidentally with a reduction in the price of phthalic anhydride. Henceforth the old uses of phthalic anhydride became of secondary importance to its use in making resins and plasticizers. National's facilities were several times increased to meet this growing demand.

Maleic acid, being also suitable for making resins, began to attract attention and in 1928 National produced maleic acid in crystalline, solid form for this use and in 1930 began the first commercial production in history of maleic anhydride. This product parallels phthalic anhydride as regards reduction in price and increase in production facilities. Fumaric acid, succinic acid, and succinic anhydride are related products introduced by National for the growing industry of resins and plastics.

In 1929 National introduced a new, bright blue food color, brilliant blue FCF, which was added to the limited list of permitted food colors after lengthy testing to meet the requirements of the Food & Drug Administration. In 1930 it entered the field of surface-active agents with the manufacture of a synthetic organic wetting agent trade-marked Naccosol A. This year National also obtained from Germany a sample of new organic detergent, Gardinol, derived from coconut oil fatty alcohols, and under a sales agreement concluded in 1932, became the first importer and distributor of the new product in the United States.

About this time National began intensified research to produce synthetic detergents from petroleum and in 1934 marketed under the trade-marks Nacconol KP and Nacconol KPR, the first synthetic alkylarylsulfonate detergents from this source. Thenceforward, synthetic detergents were to be a feature of a constantly increasing size and importance in National's activity. Detergents of improved quality and a more extensive line were developed and marketed: Nacconol KB, introduced in 1935; Naccolene F, an oil-soluble detergent suitable for dry cleaning, in 1936; and Nacconol NR, the present preferred type, in 1937. The diversified uses and widespread acceptance of these products, stimulated by the low-price policy made possible by the inexpensive petroleum base, required several plant expansions by the time of the United States' entry into World War II.

In 1933 National had introduced vat colors in the new form of instantly dispersible dry powders. Previously vat colors had been marketed almost exclusively as pastes subjected to the hazards of freezing, nonhomogenity, and inaccurate measurement. This development was followed in 1937 by vat colors in dry, nondusting flake form. Yearly addition of new color types included not only improved products in the older application classes and new vat colors, but new application classes such as azoic colors (naphthols and stable diazo salts) and colors for new textile fibers with unusual dyeing properties, such as cellulose acetate and various special rayons. In 1939 National introduced chemical ASA, a novel antiskinning agent which prevents paints and varnishes from forming a surface skin in con-

tainers but in no way interferes with normal drying. In 1940 National introduced succinchlorimide, a new type of chlorine-liberating chemical for the on-the-spot sterilization of drinking water, a use which has become important in the control of water-borne diseases of poultry. In 1941 National first produced commercially its detergents in spray-dried form convenient for household use under the trade-mark Swerl.

An obvious effect of World War II was the distortion of demand, as illustrated by National's 30-fold expansion of its production of vat khaki 2G, a fast cotton dye, swollen demand for specific blue wool dyes for navy uniforms, and a highly increased demand for phthalic anhydride for the manufacture of special coating compositions, stabilizers for smokeless powder, and insect repellents. Illustrative also are the abrupt curtailment of National's plans for spray-dried detergents for household use and the offsetting demand for flake Nacconol NR for mobile field laundries and for the manufacture of salt-water soaps which grew to absorb virtually all of National's detergent production. New requirements arising out of military necessity directed much work to the development of wholly new products. Illustrative of such was National's manufacture of special dyes for camouflage material to meet the unprecedented requirements of fastness, and for the production of colored smokes for signaling.

Besides these expected adjustments and extensions of normal Company function for the prosecution of the war, beginning in 1942 National organized, staffed, and operated an ammonium picrate (explosive D) plant for the U. S. Government at Baldwinsville, N. Y. A high-grade product was produced by an unconventional process which utilized chlorobenzene rather than phenol as raw material, thus providing relief at a time when phenol was in heavy demand and short supply. The process, though not new, was refined by National's chemists and difficulties experienced with it earlier and elsewhere were eliminated. Since the first step of converting chlorobenzene into dinitrochlorobenzene is performed on a large scale in the manufacture of sulfur blacks, a substantial portion of the processing was relegated to existing facilities of the dyestuff industry, leaving only the final steps to government facilities. Large quantities of dinitrochlorobenzene were supplied by National's Buffalo plant.

In 1943 National undertook a substantial portion of the government-sponsored expanded production of the antimalarial, Atabrine. At the peak, National was producing at a rate sufficient for 70,000,000 single-dosage pills per month. For the Committee on Medical Research of the Office of Scientific Research & Development, National's Research & Development Department developed a commercial process for, and turned out the first commercial chloroquine, an improved and preferred antimalarial drug.

National entered the postwar period on a high level of technical competence, requiring principally war-deferred construction to provide facilities for the manufacture of a large accumulated backlog of new products in and out of the dyestuff field. A pent-up, world-wide demand for National's line of organic chemicals, to supply which German industry can no longer importantly contribute, would appear to insure effective operation of the Company's facilities, existing and planned, well into any reasonably foreseeable future.

NATIONAL DAIRY RESEARCH LABORATORIES, INC., in cooperation with governmental and industrial laboratories, has pioneered in the science of dairy chemurgy—the development of new uses for the waste by-products of dairy processing. In 1929, when National Dairy Products Corp. was six years old, American farmers produced 98,988,000,000 lb. of milk, approximately 375 qt.

per capita. About 43% of this milk was consumed as fluid milk and cream. The 57,000,000 lb. not so consumed or required on the farms was known as "surplus," used to produce butter, cheese, ice cream, evaporated milk, and other salable dairy products which can keep. These products act as the balance wheel of the dairy industry. The consumption of fluid milk is fairly constant throughout the year, but milk is produced in substantially greater quantity in the spring, when the cows are in pasture. To have sufficient milk for our winter needs, we must absorb the spring "flush" production in dairy products. Further, some of the country's best pasture lands are far removed from large centers of population. The greater percentage of production in those areas goes into dairy products which can be economically stored and shipped to large markets.

It takes 10 qt. of milk to make 1 lb. butter, and nearly 5 qt. of milk to make 1 lb. of cheese. The residues, fat-free milk, buttermilk, and whey constituting four fifths of the volume of raw milk used in processing, once formed a veritable river of waste since but for buttermilk, none had any commercial use. Fat-free milk and cheese whey were fed to farm animals, but they represented a very real loss in income to the dairy farmer who had a market for only one of the components of the milk he produced.

Thomas H. McInnerney, then president of National Dairy, reasoned that economic uses could be developed for dairy by-products through research, and that such research would implement the purpose upon which National Dairy was founded in 1923—to further the dairy industry by combining the talents and resources of experienced dairymen. He discussed the matter with Dr. E. V. McCollum, professor of biochemistry at the School of Hygiene & Public Health, Johns Hopkins University, with the request that a dairy research laboratory be organized. The laboratory was established in 1929 in Baltimore, with Dr. McCollum as president of National Dairy Research Labs., Inc. National Dairy's board of directors at this time were: Clarence Dauphinot, J. M. Hoyt, H. M. Lehman, Alfred A. DuBan, H. S. Tuthill, Henry W. Breyer, Wilbur S. Scott, D. C. Eldridge, A. P. Hunt, William F. Luick, Ford Hibbard, and L. A. Van Bomel, the last now president.

The objectives were investigational work looking toward improvement in the quality of milk and milk products; utilization of dairy by-products, both for animal feeding and for conversion into various new products by means of chemical, bacteriological, mycological, and enzymic processes; investigations directed toward better understanding of the nutritive qualities of milk and its products and their values in human dietaries.

When National Dairy Research Laboratories was founded, great quantities of whey and skim milk were being discarded either because the products made from them were erratic in properties or because there was not sufficient demand from the several uses to which they could be put. Dried whey and nonfat milk products were developed for the baking industry which now uses large quantities to improve the nutritional properties of bread and the texture, crust color, and keeping quality of bread and cake. Industrial by-products have been produced from skim milk and whey for purposes which today range from nutrition to felt hats, and are still expanding.

Casein's first use was in paper coating to enhance smoothness for clearer printing. During the war years more than 24,000,000 lb. of casein were used annually for this purpose. Many of the popular new water-emulsion paints contain casein, which acts as emulsifier and binder. Casein produces a plastic used to make buttons, umbrella handles, buckles, and costume jewelry. It is used in insecticides, in building materials, and in adhesives. In 1941 the first chemically stabilized pro-

tein fiber to be produced by man was introduced as Aralac and has since taken its place among the recognized textile fibers.

In the middle 1930's, National Dairy Laboratories succeeded in digesting casein with acid to separate its constituent amino acids. The product is called HY-Case and is used in food processing to enhance flavor, as mixed amino acids for human nutrition, and in the production of microbiologicals. Improvements made this product capable of serving as a base for amino acids for intravenous use. A more recent development is an enzyme digest of casein known as N-Z-Amine, which is extremely valuable as a supplement to the normal protein diet or for medical administration in stomach ulcers, malnutrition, and severe burns. A second use is for commercial growth of such microorganisms as penicillin, streptomycin, and diphtheria toxin. During the war N-Z-Amine was a top-secret, high priority item with the Chemical Warfare Service.

A third enzyme digest of casein, N-Z-Case, is used to grow hard-to-cultivate varieties of organisms for the laboratory and is recommended by the National Institute of Health. Many other types and grades of casein have been developed for specific uses. In addition to industrial caseins, other producers of casein offer mixed amino acid products, edible casein, calcium and sodium caseinates, and casein glue powders. During the war years, the Laboratories used more than 60,000,000 lb. of casein annually, the product of nearly 2,000,000,000 lb. of fat-free milk. The constant program of research carried on by National Dairy is continuously enlarging the use and improving the quality of this wonder product.

Whey is the residual liquid when casein is removed from fat-free milk. Dried whey products have been developed for the baking industry to enhance the nutritional properties and to improve texture and other qualities of bakery products. A baking laboratory has been established for control, to insure uniform satisfactory quality of the dried whey. Dried whey is also used as animal feed. Containing large quantities of calcium, phosphorus, and riboflavin, it is highly valued in poultry feed as a preventive of poultry diseases and to increase the hatchability of eggs.

The separation from whey and the use of the natural protein, lactalbumin, have assumed importance only within the last several years. Lactalbumin contains an excellent assortment of the more desirable and the essential amino acids. Edamin, a hydrolysate of lactalbumin, is an enzyme digest used orally for supplementary protein feeding or therapeutic purposes. Another whey component, lactose, a true sugar, does not absorb moisture from the atmosphere and for this reason is widely used as a coating or filler in making pharmaceutical pills and tablets. It is also added to cow's milk to make it more comparable to mothers' milk for infant feeding. Considerably larger demands were created for lactose by the discovery during the war that it was valuable for growing penicillin.

Ferric lactate, an iron supplement used in the complete baby food, Formulac, was developed by National Dairy chemists. Calcium lactate is used directly as a pharmaceutical and in baking powder and foods to enhance calcium content. Sodium lactate is used industrially because it absorbs and holds atmospheric moisture and because of its viscosity in solution. Lactose may be fermented to lactic acid. Further refinement of lactic acid results in a number of industrial uses in baking powder, in foods to increase their calcium content, in pickles and fruit preparations to give an acid tang, and only recently copper lactate has been used for electroplating. Lactose is also fermented to produce alcohol and vinegar. Over 1,000,000 gal. of vinegar were so produced by National Dairy in 1946. The residue from fermentation of lactose in whey, known as delactosed whey, contains lactalbumin and yeast. It makes a valuable component of animal food.

With every advance made by dairy chemists, the waste is being turned into additional dollars for the farmer and into new, improved products for the consumer. To enlarge its scope of research, National Dairy has moved from Baltimore to Oakdale, Long Island, N. Y., where more complete research facilities are available.

The current board of directors, which has wholeheartedly supported president Van Bomel's emphasis on National Dairy's research activities, is composed of F. J. Andre, F. J. Bahl, Edgar N. Brawner, Henry W. Breyer, Jr., Paul C. Cabot, Joseph Gilfillan, Robert S. Gordon, B. S. Halsey, Vernon F. Hovey, John H. Kraft, B. M. Lide, Jr., Elmer J. Mather, Thomas H. McInnerney, H. H. Neel, P. P. Miller, G. C. Pound, E. E. Stewart, Henderson Supplee, Jr., L. A. Van Bomel, H. C. Von Elm, and Sidney J. Weinberg.

NATURAL PRODUCTS REFINING COMPANY was founded in New York in 1909. Henry A. Goman, Clarence V. Steinhart, and Richard L. Weil were the original officers and directors. The New York corporation transferred its assets to Natural Products Refining Co. of New Jersey, in 1917, and that company in turn transferred its assets to the present company which was incorporated in Delaware in 1923.

The plant was established in Jersey City, on Garfield Ave., and has remained at that location. It covers approximately five acres and consists of 33 buildings, serviced by the Newark Branch of the Central R.R. Co. by private siding. General offices are also at the Jersey City address.

Henry A. Goman, the founder, was born in Macon, Ga., 1876, studied metallurgy at Stevens Institute and chemistry at the University of Freiburg in Germany. He served as the chairman of the board of directors until 1917, and as president from that time until his death in 1945, when he was succeeded by his widow, Frances S. Goman, now Frances S. Ferguson. Clarence V. Steinhart was associated with the Natural Products from 1909-29, serving as vice-president at the time of his retirement. Richard L. Weil was secretary and treasurer from 1909-16. Upon his death in that year, his brother, Stanley L. Weil, became associated with the Company and served as vice-president and treasurer until his death in 1941. James S. Hollowell, who retired in 1947, was associated with the Company for over 30 years, and at the time of his retirement was vice-president in charge of engineering. Charles W. Bogart, for over 37 years with the Company, was successively assistant secretary, assistant treasurer, and is now vice-president and treasurer. S. W. Stanton has been with the Company since 1915, now as vice-president in charge of sales. Theodore Rurode was general counsel from 1918 until his death in 1930, when he was succeeded by his son, William S. Rurode.

The present officers of the Company are: F. S. Ferguson, president; C. W. Bogart, vice-president and treasurer; S. W. Stanton, vice-president, sales; W. S. Rurode, secretary, Dr. Arthur Rosinger, chief chemist and director of research and development; Mario J. Portanova, assistant chief chemist; John Nygren, plant engineer; and Louis R. Papp, superintendent.

The Company's first product was bichromate of soda. This was followed successively by bichromate of potash, anhydrous sodium sulfate, and anhydrous chromium sulfate. The Company has produced at times chromium hydroxide, chromic acid, aluminum hydroxide, aluminum oxide, and aluminum sulfate. The manufacture of these latter products, with the exception of aluminum hydroxide, has been discontinued because of the greater requirements for bichromates. The Company has enjoyed a continuous growth since its founding, and served the country's requirements for chromium salts during the First and Second World Wars, receiving special mention from the War Production Board.

NEVILLE COMPANY owes its origin to conditions arising from World War I. When the United States' supply of German coal-tar chemicals was cut off, our Government called upon the steel companies to build by-product coke ovens for the production of metallurgical coke and derivative chemicals. With the return of peace, extensive facilities for the production of coal-tar raw materials existed here. It was to market these products, in a brokerage capacity, that the Neville Co., originally named the Neville Chemical Co., was incorporated in 1926 by Harvey N. Dauler, William S. Gardiner, and Edwin Hodge, Jr. In little more than a year, however, realization of the opportunities for development of an American coal-tar chemical industry and of the shortage of processing plants for these products, led the founders to expand the scope to the manufacture of oils, solvents, and synthetic resins. In 1927 a plant was constructed on Neville Island in the Ohio River, several miles below Pittsburgh. In this area well over 60,000 tons of bituminous coal are carbonized daily in by-product coke ovens to fill the needs of surrounding steel mills.

Dauler, Neville's first president and now chairman of the board, started his career as an oil salesman, opening what is generally accepted to be the world's first gasoline service station on Bigelow Boulevard in Pittsburgh. He later bought the Beaver Refining Co. of Washington, Pa., and began there a lasting relationship with Gardiner, who was to become Neville's vice-president and secretary. Gardiner had been with the Panhandle R.R., joining Beaver Refining to assist in handling its heavy traffic from Western oil fields. Dauler had previously also organized the Dauler Oil Co., which marketed coal-tar products as well as petroleum.

Hodge, now president, had an extensive background in the steel and railroad industries. Today he is chairman of the board and president of Pittsburgh Forgings Co. and Greenville Car Co.; director and member of the executive committee of Pittsburgh & Lake Erie R.R.; and director of Mackintosh Hemphill Co., Union Spring & Manufacturing Co., McKeesport & Youghiogheny R.R. Co., Shenango Valley R.R. Co., and National Supply Co.

Under these men the new Neville Island plant launched the manufacture of coumarone-indene resins and coal-tar solvents. The resins varied from viscous liquids to hard, brittle solids marketed under various trade names, among which Nevindene, and the "R" and "G" became particularly well known. They found use in mastic composition floor tile, protective coatings, bubble chewing gum, rubber products, wax preparations, stiffeners, and inks. Primary objectives in resin manufacture were low cost, good solubility, and wide compatibility. The solvents group comprised such aromatic hydrocarbons as benzene, toluene, Tollac solvent, Nevsol, Refined Light Solvent, hi-flash solvents, and rubber-reclaiming solvents.

From the first, a favorable reception and broadening markets were accorded these products. Sales at the start were made directly by the Company; but as volume increased, marketing was placed with independent sales agencies in the major chemical-manufacturing centers. As the demand increased, contracts were also entered into with distributors in foreign markets.

In 1931, to round out its coal-tar products, Neville purchased the adjoining plant and property of the Island Petroleum Co., which enlarged the production area to 58 acres. For about seven years the refining equipment acquired was used for production of road tar. Experience soon showed that tar paints and other specialized tar products could be produced to even better advantage. Eventually some equipment was converted to resins and compounding oils now used in reclaimed and synthetic rubbers. Other parts of the plant were utilized for chemical pro-

duction, and the wholesaling of petroleum products—gasoline, lubricating oils, and greases. Benzol-blended motor fuels were a major item.

While these production and marketing programs were being expanded in the first half of the 1930's, the Company had begun experiments with new products. The work of Joseph Rivkin, one of its research chemists, toward creation of a phenolic modified coumarone-indene resin came to successful fruition in 1935, in the new product Nevillac. Alcohol-soluble and having a wide range of compatabilities, this resin was particularly valuable in adhesives, as an antiskinning agent for paints, and in paper coatings. It was the first modified coumarone-indene resin and represented the first fundamental improvement in the manufacture of coumarone-indenes in 20 years.

To expand such efforts and match the growth of the Company, a complete research laboratory building was put in operation in 1936 under William H. Carmody, Neville's first director of research. One of the laboratory's first accomplishments was Nuba, a low-cost, dark-colored resin used primarily in shoe stiffeners and thermal-insulating compounds. Other notable early developments were the Cosols, refined coal-tar solvents, and a number of other special blends and cuts. In 1937 a hydrogenated coumarone-indene resin was developed which was water-white and entirely soluble in petroleum solvents and mineral oils. Named Nevillite, it found use in pressure-sensitive adhesive tape and in varnishes which did not after yellow. Nevillite and the other research products were patented.

The scope of the research work, now headed by Lyle M. Geiger, has steadily increased. By the end of the 1930's the Company's products included Clarite, a water-white transparent, high-melting cycloparaffin resin for mounting histological tissues; Nevtar, a tar paint; 465 Resin, a dark coal-tar resin for varnishes and mastic floor tile; wire enamel solvents; rubber-reclaiming solvents; oils such as Nevoll, a coal-tar softener and plasticizer for synthetic and natural rubber; creosote oils for wood preserving; shingle stain oils; gas-holder oils; and neutral and tar-acid oils for disinfectants. Plasticizing oils such as Nevinol, Nevillite Oil, and P.H.O., all neutral, nonsaponifiable, and widely compatible with resinous materials and insoluble in water, were also manufactured.

In its first 15 years, Neville's products had become known the world around. Sales agencies were established in England, Australia, Italy, Germany, France, Sweden, China, South America, Mexico, Canada, and most other important countries.

Neville developed Nevtex to meet the need for a resin in compounding flameproof and waterproof compounds for coating cotton duck for the Armed Services, in the Second World War. It began manufacture of dibutyl phthalate as binder for smokeless powder, using its own funds to erect the necessary plant on its property. At Government request, guanidine nitrate, a comparatively rare chemical used as an antiflash component in artillery shells for one of the United Nations was also manufactured. Large-scale munitions manufacture meanwhile had brought about a severe shortage of toluene, causing a near crisis in the nitrocellulose lacquer industry. Here Neville was able to provide millions of gallons of Tollac and Nevsol solvents as substitutes. Nevoll, dibutyl phthalate, and various Neville solvents were useful in the new synthetic rubber program for softeners, oils, resins, and solvents for tires, insulation, cements, and other products. Reclaiming oils were also furnished for digester and pan processes used in rubber reclaiming.

Neville's regular products had hundreds of military applications, from antifouling ship-bottom paint to ice-preventive oil and insecticides for controlling pests in the Pacific jungles. Out of the last grew the Company's interest in exterminators, which led to research and production of phenothiazine, an anthelmintic for

farm animals. Cooperating with the Department of Agriculture, Neville was among the first to initiate manufacture of this coal-tar remedy and is today one of its major producers.

Indicative of the rapidly expanding field of its interests, the Company's most recent bulletin listed 25 new experimental products, whose uses at the time were undergoing research and development in the laboratories of hundreds of potential consumers.

Present Neville officers besides Dauler, Hodge, and Gardiner, are Lee V. Dauler, vice-president in charge of sales; David W. Kelso, treasurer; and John C. Bane, secretary.

NEWPORT INDUSTRIES, INC., was organized, Sept. 5, 1931, to acquire the Wood Distillation Division of the Newport Co., which company was soon dissolved. The Newport Co. was originally controlled by the Schlesinger interests of Milwaukee, headed by Ferdinand Schlesinger and his two sons A. A. and H. G., as were a group of associated companies, Newport Mining Co., Newport Hydrocarbon Co., Newport Chemical Works, Milwaukee Coke & Gas Co., and several coal-mining properties.

The Wood Distillation or Naval Stores Division goes back to 1912, when Vera Chemical Co. of Milwaukee was manufacturing paper chemicals, including paper size made from gum rosin. Rosin sources other than the living pine tree were sought and attention was directed to pine stumps, vast areas of which were available along the Gulf Coast from yellow pine lumbering operations. Vera Chemical induced the Schlesingers to construct a factory at Bay Minette, Ala., to operate the new distillation and extraction process. This company was called Newport Turpentine & Rosin Co. Production began in 1913 under the management of William B. Logan, assisted by Alfred James, both of whom were transferred from Milwaukee Coke & Gas Co. James later became general superintendent of operations for all Newport naval stores plants, until his retirement in 1945.

The present management has been associated with Newport for many years. Armin A. Schlesinger, active in the early Bay Minette plant, is now chairman of the board. John H. McCormack, president of Newport, who succeeded Logan as manager of the Wood Distillation Division in 1919, started as a chemist with Newport in 1916 in the Carrollville works. Other chemists at Carrollville in 1916-17 were Seymour J. Spitz, now executive vice-president, and Herbert L. Marter, now vice-president in charge of production. Robert C. Palmer, vice-president and chemical director, came to the Company as chief chemist of the Wood Distillation Division in 1916 from the U. S. Forest Products Laboratory at Madison, Wis. Ernest E. Holdman, director and manager of foreign sales, has been in the marketing of Newport wood naval stores since the early Bay Minette days, having been formerly with the General Naval Stores Co. Edmond F. Sisson, vice-president in charge of engineering, came to Carrollville in 1924, and Carlisle H. Bibb, vice-president in charge of research, joined the organization in 1935. Frank S. Bickford, secretary of Newport Industries since its inception, has been with Newport interests since 1916. John J. McCabe, who became treasurer in 1936, joined Newport in Milwaukee in 1917.

Prior to the entrance of the United States in World War I, Newport began producing coal-tar chemicals, intermediates, and dyes at Carrollville, Wis., to provide an outlet for the raw materials from its Milwaukee Coke & Gas operation. Among other installations was a synthetic phenol plant, having an ultimate production of 130 tons per day, at that time probably the largest in the world.. After the war and during the 1920's the manufacture of dyestuffs was greatly expanded.

All these Northern chemical properties were sold in 1931, prior to the organization of Newport Industries, Inc.

The early Bay Minette operation consumed about 70 tons of waste wood per day. With the experience gained there, it was decided to erect a second plant at Pensacola, Fla., in 1916, with a capacity of 150 tons of wood per day. The Acme Products plant at DeQuincy, La., operating under the same process, was built in 1921 by the Gillican-Chipley interests, large gum rosin dealers, factors, and producers. This plant, with a capacity of 150 tons per day, was acquired by Newport in 1928. Each of these three installations was subsequently expanded until the combined capacity is now about 1,100 tons per day. This will be increased to 1,600 tons when construction is completed on a fourth operation at Oakdale, La. It is estimated that approximately 6,500,000 tons of stumps and waste wood have so far been processed by Newport.

The first products at Bay Minette were wood rosin, steam-distilled wood turpentine, and steam-distilled pine oil, all very crude. The rosin was dark in color and too soft for general use. It even proved unsuitable for paper size, which had prompted the venture. The turpentine had an entirely different odor from gum turpentine and was too slow-drying for a good paint thinner. The pine oil was considerably higher boiling than turpentine and comparatively new to industry, as it is not a product of gum naval stores. Early research was, therefore, directed to making these products marketable. This was largely accomplished by 1916, although the rosin was still dark in color and the oil products were none too good.

Fortunately, demands just prior to and during World War I were sufficient to consume the entire production from both Bay Minette and Pensacola. But the business depression of 1921 taught that if the business was to succeed and expand the products would have to be improved much further. Wood rosin would have to be produced in paler grades to be competitive with gum rosin. A program of research was then instituted with this primary objective, and after about seven years the problem was solved and rosins of extremely pale grades were brought into production. Patents were issued and the processes are still in operation. The natural, dark wood rosin was known as FF grade. To produce a "water-white" rosin, it was necessary to remove a substantial amount of very dark resin wholly unlike rosin in many respects, which created a by-product problem. Study and research finally developed products from this new raw material and markets were found.

Work on refining the oil products went along concurrently with the rosin research, and a third oil product, dipentene, was added to the list. The separation of dipentene insured turpentine of greatly improved quality. The composition of pine oil became well understood and many grades were developed and their uses expanded. Most of this research was carried out in the laboratories at Pensacola, although supplemented at Carrollville.

All marketing in the early days was handled by General Naval Stores Co., which was owned by Benjamin H. Baker, an old hand at marketing tar, pitch, and other products of the older destructive-distillation industry, as well as gum naval stores. In the late 1920's and early 1930's, to put more technical effort into the marketing phase of the business, General Naval Stores Co. was fortified by a technical sales staff, which maintained a sales service laboratory at Cincinnati, later moved to Passaic, N. J. Newport then took over General Naval Stores and Seymour J. Spitz became president of the Sales Division, with headquarters in New York, offices in Chicago, Cincinnati, Philadelphia, and Memphis, and agents in all the principal cities and abroad. The laboratory facilities of the Technical Sales Department were transferred to Pensacola.

An appreciable portion of Newport's naval stores products was exported prior to World War II, and technical sales representatives were maintained in England, Germany, Scandinavia, Italy, South Africa, India, Australia, and several South American countries, normally large consumers of turpentine, rosin, and pine oil.

After the extraction of the naval stores products, the wood as spent chips provided the fuel for the operation. For many years prior to 1928 Newport had studied other methods of utilizing these spent chips. In 1928 a joint research program was undertaken with the Armstrong Cork Co., looking toward the manufacture of insulation board from this waste. The research was completed in 1930 and a mill erected at Pensacola with an initial capacity of 35,000,000 board feet per annum. In 1938 Armstrong acquired Newport's interests and continued the operation alone.

During the 1930's Newport expanded its research program toward the production of terpene and rosin chemicals and their derivatives. In 1935 the business and assets of Oxidation Products Co. were purchased. This company was producing terpene derivatives from pine oil, and research was under Carlisle H. Bibb, who came to Newport at the time of the purchase. A terpene chemical plant was erected at Pensacola and U.S.P. camphor, fenchone, α- and β-terpineol, anethole, and new terpene solvents were added to Newport's line. The processes, all patented, are still in operation.

The dipentene separated from turpentine was sold as a special solvent for a limited market. Research directed to its use as a chemical raw material led to the manufacture of *p*-cymene, *p*,α-dimethylstyrene, *p*-menthane, and methyl-acetophenone. The processes involved were also patented.

In the late 1930's Newport's chemists studied the possibility of making isoprene from dipentene, and with the advent of World War II were ready with a process. A plant was erected at Pensacola and for many months Newport's isoprene was the only source of this important ingredient for Butyl rubber and freeze-resistant rubber.

The ratio of rosin to oil products derived from pine waste wood being about 3.5:1, it was natural that rosin should receive its proportional share of development research. Even before the color problem was solved, special rosins hardened with lime and soda ash were in production. Special treatment finally made the natural rosin suitable for sizing kraft paper and thus the original objective for constructing the Bay Minette plant was realized.

With the advent of pale rosins during the 1930's, many specialty rosins produced by heat or chemical treatment to effect polymerization or conversion to resinates of extreme hardness were developed. Solutions of these products in the form of gloss oils followed. Most of the processes and some of the products are covered by patents. Each new modification was aimed at some particular industry. A very substantial portion of the rosins or resinate now produced are classed as chemicals. Many of them were made to order to comply with the special physical or chemical properties requested by consumers.

The markets for the three primary products originally made at Bay Minette were limited to a half-dozen industries. Today the uses of the various products touch most of the basic industries, ranging from insecticides to perfumes, from pharmaceuticals to the rubber industry, textiles, soap, the vast paper industry, and almost every type of protective coating.

For many years Newport recognized that the by-products obtained from kraft paper mills, known as tall oil, would one day be an important source of rosin and fatty acids. Research in this direction was begun in the late 1930's. Refined tall oil and its varnish oil are the latest addition to Newport's line of products. It is also

planned to separate the highly refined fatty acids and rosin by an entirely new patented process.

In 1940 Newport's engineers became interested in the fiber, ramie. An experimental plant was erected at Atmore, Ala., and the agronomy and processing of ramie were studied. Test plantings were made in the Florida Everglades. The Atmore development was abandoned in 1943 and all efforts were concentrated in Everglades. Over 1,200 acres of ramie were planted and a decorticating plant was completed early in 1946. This is a joint venture with the United States Sugar Corp., which owns the land on which the ramie is grown and the plant located.

Newport Industries' original capital structure consisted of 519,347 shares of capital stock of $1 par value, with a paid-in surplus of $3,326,164. In 1938, 102,012 shares were taken by stockholders at $10 per share. The proceeds were used to liquidate a $400,000 loan then outstanding and for certain capital expenditures. In Jan. 1946, 40,000 shares of 4¼% preferred were sold principally to provide capital for a new plant at Oakdale, La. As of June 30, 1946, the capital structure consisted of 621,349 shares of common and 40,000 shares of preferred; total surplus, $5,509,651.

NIAGARA ALKALI COMPANY of today is the culmination of a long series of intensely practical pioneering ventures going back nearly half a century. Electrochemical processes were still new to industry in 1900 when Isaiah Roberts and Wesley Block formed the Roberts Chemical Co. to produce chlorine and caustic potash electrolytically from imported muriate of potash, at Niagara Falls. Even electricity was not a little glamorous and magical then. Roberts had devised an improved electrolytic cell and was seeking capital for its development. Block had lately realized on a fortunate investment in the gas-mantle business of the Welsbach Co. and was looking to reinvest his capital. With the rapid rise of electric lighting, it was natural he should seek a new opportunity in an activity utilizing electricity.

At that time Niagara Falls Power Co. was just getting under way and was anxious to encourage likely customers who might use large and continuous blocks of electricity. The Roberts Chemical Co. was just such a prospect and was able to buy power on exceptionally favorable terms under a long-term contract that turned out to be one of the most valuable assets of the Company.

The original plan was to produce caustic potash, never before made in America, and thus give the new enterprise an advantage by avoiding competition with larger producers of caustic soda. Actually the choice of potash enabled the Roberts cell to operate as it probably could not have done on soda. From a sales point of view the difference was vital; later events showed up other reasons.

The success of the project in final analysis depended on the efficiency of the Roberts cell in day-to-day operation. The cell, however, was cumbersome and certainly by modern standards not particularly efficient. Accounts of early operations tell of chlorine always loose in the cell room in spite of several ventilating fans, and of frequent explosions of chlorine-hydrogen mixtures accidentally formed. Events early proved that profitable production of bleaching powder under the circumstances was unlikely in view of competition from much larger, more economical operations. That spurred Roberts to invent a burner for converting chlorine into very pure hydrochloric acid. The process was highly successful, although actually it was used more widely abroad because no demand for high-purity acid existed in this country at that time great enough to absorb all of even the Roberts output.

The Roberts burner was particularly important because it soon attracted strong-

arm interference from German chemical interests. All of Roberts' muriate of potash had to be bought from the German potash syndicate which then controlled the world supply. Furthermore, the Germans could sell caustic potash here at ruinous prices whenever they wished. Being entirely dependent on a very limited output of caustic potash and comparatively minor amounts of hydrochloric acid and bleaching powder, the Roberts Co. was at their mercy. That lent particular value to any outlet for the smaller company's products that would be out of reach of the German combine, and thus sharpened the natural pioneering instinct of the Americans.

E. D. Kingsley and Bernard C. Hesse, a few years later, were looking for a source of chlorine to submit to liquefaction, a process then entirely new in the United States. The search began after much time and money had been spent to demonstrate the practicability of liquefying American chlorine and using the liquid directly as a bleach. This demonstration had followed experiments involving treatment of the chlorine itself with an electric current, adaptation of several types of compressors to liquefy the extremely corrosive gas, and finally importation of usable compressors and cylinders from Germany where liquid chlorine was already a commodity. The Electro Bleaching Gas Co., formed by Kingsley and Hesse, located its operation adjacent to Roberts' to use any surplus chlorine. While E.B.G. was soundly financed, it could not help Roberts directly. Its sales of liquid chlorine had to be made at a loss in the early days even though the price was 25¢ per lb. It was years before it was financially secure enough to help others.

Meanwhile German pressure on the Roberts Chemical Co. grew and, helped by the inefficiency of the Roberts cell, the Germans in 1910 obtained control of the enterprise through a mortgage given by the Company to secure advantages of raw material. Roberts' most valuable asset was its contract for power at a continuing low rate. The new owners, principally the Kaliwerke Aschersleben, were represented by the International Agricultural Corp. (now the International Minerals & Chemical Corp.). Thomas C. Meadows and H. D. Ruhm, both connected with International, were prime movers in organizing the Niagara Alkali Works to take over the assets of the Roberts Chemical Co. and to continue its business. The new company, of which Ruhm was president, E. M. Sergeant, vice-president, and F. O. Geyler, secretary-treasurer, was incorporated in New York, Mar. 11, 1910. Immediate steps were taken to enlarge materially the output and to replace the Roberts cell with the more efficient Siemens-Billiter cells then in successful operation in Germany. A new 750 kw. power plant, new evaporators, and new bleach chambers were installed. All of this was in operating order and running during the spring of 1911. By the fall of 1912 the plant was almost doubled in size and production of caustic soda was added. This was followed by the first production of flaked caustic in the United States.

In 1913 the Electro Bleaching Gas Co. undertook and successfully carried out a revolutionary experiment in sterilizing the public water supply of Niagara Falls, using chlorine. Previously the death rate from typhoid fever in the city had been astoundingly high, and its active tourist trade carried the disease to all parts of the country. However, after the treatment was well under way, even though the equipment used was crude, the incidence of typhoid fever in Niagara Falls dropped precipitously. This venture became an example to cities throughout the country and abroad, and efficient equipment for applying chlorine to water was developed during the succeeding years.

In 1914, using some of its by-product chlorine, Niagara Alkali initiated the production of chlorobenzene, which was in ready demand by the National Aniline Co. of Buffalo as an intermediate in the production of sulfur black. The same year

it elected Albert Plaut, president of Lehn & Fink, New York pharmaceutical manufacturers, to be chairman of its board of directors, and F. W. Fink, its president. This regime was short-lived and in the fall of 1915 the entire capital stock of Niagara Alkali was acquired by Electro Bleaching Gas, now grown prosperous. Both companies continued their separate existences under president E. D. Kingsley until July 1, 1941. At that time, Kingsley became chairman of Niagara Alkali and J. C. Cassidy, president. Both the predecessor companies were combined under this name and a single management.

The Niagara Alkali Co. in 1918 had acquired the Pacific Lime Co., Ltd., producers of high-quality lime products distributed in Canada and the Pacific Northwest, and the Kingsley Navigation Co., Ltd., engaged in freighting general cargoes on Pacific coastwise runs.

The prosperity of the Electro Bleaching Gas Co. came quite definitely from its pioneering. It introduced liquid chlorine successfully into the textile trade as it had into public water sanitation. In 1919 it introduced liquid chlorine into the American and Canadian pulp and paper industry where it has since completely replaced bleaching powder. Subsequently it also pioneered in the successful bleaching of shellac with chlorine. Meanwhile Niagara Alkali delivered the first electrolytic hydrogen used for the synthesis of ammonia to the neighboring plant of the Mathieson Alkali Works in 1926. Three years later the Billiter cells inherited from its German connections were replaced by an improved, more efficient type of Gibbs cell.

Other pioneering activities included the first American production of electrolytic caustic potash low in iron (1935) and in chlorine (1938), as required for alkaline nickel electric storage batteries. This followed by several years the Company's production of a special grade of electrolytic caustic soda low enough in both iron and chlorine to be satisfactory for making viscose rayon. In 1943 the Company began the first commercial production of tetrachlorophthalic anhydride (Niagathal), which promises to be chemically useful. It was also the first purchaser for chemical purposes of American muriate of potash, an event which marked the end (1933) of foreign domination.

Financially, the Company's bonds and outstanding preferred stock have all been redeemed. The substantial expansion of operations, plant, and property necessitated by the preparedness program and war demands for Niagara Alkali products were fully met and financed by the Company itself.

The present officers are: J. Clarke Cassidy, president; S. Willard Jacobs, vice-president; Stephen J. White, vice-president and treasurer; and Harold J. Mowry, assistant treasurer. On the board of directors are Cassidy, Jacobs, White, Dwight K. Bartlett, H. L. Morehouse, Wm. J. Weed, and Daniel F. Wheeler.

NIAGARA CHEMICAL DIVISION, Food Machinery Corporation, traces its origin to a group of local citizens of Middleport, N. Y., who formed a company about 1905 to promote a "gas" spraying machine for agricultural use, invented by Ernest B. Freeman of Middleport. This machine could spray Bordeaux mixture, then in common use, under pressure onto the fruit trees without the use of a gas engine or pump. This was accomplished by means of ejecting CO_2 gas from a compression cylinder onto the surface of the liquid contained in an iron tank.

The invention soon ran into difficulties because of the discovery of lime and sulfur solution (calcium polysulfide) which was incompatible with the gas in the sprayer. The original company was therefore liquidated and taken over by the Niagara Sprayer Co., whose principal sponsors were C. P. Hugo Schoellkopf,

well-known Buffalo capitalist then identified with National Aniline & Chemical Co.; Charles B. Shafer, local grower and dealer in fruits; George F. Thompson, local attorney for the group; and Theodore Dosch, Western salesman whose brother was associated with the production of lime and sulfur solution in the Northwest. With Theodore Dosch manager of operations, this company erected a lime and sulfur solution plant at Middleport and abandoned the gas sprayers in favor of a gasoline-operated 3-cylinder triplex pressure pump.

Business was largely centralized in the Western New York fruit belt, then the nation's leading production area for quality tree fruits. Expansion of the Company's markets for lime-sulfur solution was deterred by the high freight rates on the liquid material until a National Aniline chemist, Alfred Halland, substituted sodium for the calcium base of lime-sulfur solution, producing so-called Soluble Sulphur Compound (sodium polysulfide), which could be shipped in the dry form to distant markets. A plant for its production was erected at Middleport and the Company further expanded by undertaking distribution of insecticides such as lead arsenate, Paris green, etc., made by other manufacturers.

About 1914 a Technical Department was organized in charge of a young horticulturist, Ernest Hart, just graduated from Michigan State College, and a chemical laboratory was erected at the plant, in charge of a young chemist, Max L. Tower. Scientific work was started immediately toward the elimination of all water from insecticides and fungicides. Promotion and production of material which could be put onto vegetation in a totally dry state, i.e., dusting, was of paramount interest. Engineers were put to work to develop the necessary apparatus for producing the dust and a suitable dusting machine for applying the dust. As soon as the popularity of the dry method had reached a point where all of the facilities were necessary to produce dusting machines, the manufacture of liquid spraying machines was discontinued. The Company was a pioneer in this dusting program and has maintained its leadership in this generally accepted method of treating fruits and vegetables to control insects and diseases.

In 1919, when the U. S. Department of Agriculture discovered the value of calcium arsenate against the cotton boll weevil, Niagara Sprayer began a substantial expansion of plant facilities at Middleport to include production of calcium arsenate and lead arsenate. In 1921 George F. Thompson, then state Senator from the local district, became managing director, and Ernest Hart, vice-president and sales manager. The Technical Department was expanded and the Company now took up the general production of all standard insecticides used wet and dry.

In 1927 C. P. Hugo Schoellkopf, president, died and next year the Company was reorganized and refinanced under his son, Alfred H. Schoellkopf, then associated with the Niagara Falls power interests. The name was changed to Niagara Sprayer & Chemical Co., Inc., with Alfred H. Schoellkopf, president; J. B. Cary, vice-president and general manager; B. E. Vosteen, secretary-treasurer; Ernest Hart, vice-president and sales manager; and C. A. McDonald, assistant secretary-purchasing agent. Immediately the Company began to acquire additional production facilities in Canada, on the Pacific Coast, and in Florida. From this period until 1943, the Company's sales increased and many new and unique products were developed.

In 1942 the Company's chairman and the principal stockholder, Alfred H. Schoellkopf, died suddenly and his executors interested the Food Machinery Corp. of California in buying the controlling stock in the Company, which was held by the Schoellkopf estate. Subsequently all the remaining stock was acquired by this corporation. As of Jan. 31, 1946, Niagara Sprayer was dissolved and thereafter operated as a division of Food Machinery Corp. which was thus able to round out

its manufacturing program to include chemicals as well as the various types of machinery used in the raising and processing of farm products, particularly food. In this new setup the Niagara Division now has the benefit of the Central Research and Central Engineering Research Departments of Food Machinery at San Jose, Calif., to carry on a modern research program.

Acquisition of Niagara Sprayer did not alter the operating personnel, but did result in the construction of a large research laboratory at the Middleport plant and the acquisition in 1944 of a manufacturing plant in Texas, formerly operated as the Coastal Chemical Co. of Harlingen. During 1946 plants have been erected at Richmond, Calif., and New Orleans, with additions to the Jacksonville, Fla., and Middleport plants, and a new mixing plant and warehouse at Pompano, Fla. Plans are being projected for enlarging the Canadian facilities and for another mixing plant in Florida.

The Company today manufactures or processes practically all standard insecticide materials used in agriculture, primarily with respect to arsenicals and insecticides and fungicides based on sulfur, as well as the newer organics. In the industrial chemical field a substantial volume of all grades of sulfur is being manufactured.

NOPCO CHEMICAL COMPANY in 1907 was a $1,000, two-man venture called the National Red Oil & Soap Co., with rented quarters in the basement of a Newark, N. J., factory. Today it is a nationally known $10,000,000 organization, owning and operating plants at Harrison and Flemington, N. J., Cedartown, Ga., and Richmond, Calif., with sales offices and warehouses at strategic points throughout the country. The sole assets of the embryo company, which was organized in New Jersey by two enterprising young men, Charles P. Gulick and Arthur Phillips, were a few wooden vats and a couple of paddles; its line, a single product—sulfonated vegetable oil employed in textile dyeing and offered to the trade under the alliterative name of alizarin assistant. Up to that time, raw cod was almost exclusively used by the tanning industry in processing leather. National Red Oil experimented with and produced the first sulfonated cod oil, which it promoted to the tanning industry nationally. Finding ready acceptance, this is still a staple raw material in processing many types of leather.

Increased production necessitated expansion, and in 1910 a plant, including laboratory facilities, was built on rented ground in Harrison, N. J. Subsequently, a research program was initiated to insure a sound basis for future development. Under this new setup, the line of products was enlarged to include many new types of sulfonated oils made from a variety of animal, vegetable, and fish oils, for more diversified industrial application.

Four years later, through reinvestment of earnings and entirely without new capital, a landsite was purchased in Harrison, and a larger plant erected which had a railroad siding and tidewater shipping facilities. Shortly thereafter, the National Red Oil & Soap Co. became the National Oil Products Co., or more familiarly, Nopco. Its laboratories developed the emulsifier, Albasol, and introduced it to the petroleum industry as a soluble cutting-oil base. Albasol was a factor in the production of shells and munitions for the Government during World War I. Subsequently, a subsidiary, the Metasap Chemical Co., was incorporated at Harrison for the production of metallic soaps, such as the stearates, palmitates, and oleates of aluminum, calcium, zinc, lead, and other metals. Manufacturing facilities were shortly augmented with the erection of a plant in Chicago.

In 1928 Nopco entered the vitamin field. For several years prior to that time, the U. S. Department of Agriculture, as well as many state colleges, had investigated the value of vitamins A and D for poultry and animal husbandry.

Nopco, at that time one of the largest American importers of cod liver oil, started experiments in its own laboratories which resulted in its production of vitamin D for animal and poultry feeding. Some time later, Dr. Theodore F. Zucker of Columbia University discovered a method of extracting vitamin D from cod liver oil and concentrating it. He gave the process to Columbia, which, in turn, selected Nopco as sole licensee under the Zucker patent, with exclusive rights to produce and distribute vitamin D element to the food, animal feed, and pharmaceutical industries.

Company expansion continued with the acquisition of the Brown Jeklin Co. of Seattle, Wash., and Portland, Ore., which distributed vitamin products for animal and poultry feeding in the Pacific Northwest, and the incorporation at Harrison, N. J., of another subsidiary, Admiracion Laboratories, to produce and market shampoos and other cosmetics. Admiracion was one of the first manufacturers in the country to promote soapless shampoos and detergents. Additional land and buildings were added to the Harrison plant in 1936, at which time a 52-acre tract, with considerable manufacturing facilities, was also purchased at Cedartown, Ga. All manufacturing at Chicago and part of that at Harrison were transferred to this new plant. In that same year, the Galen Co. of California, which produced vitamin B elixirs from natural sources, was acquired. In 1938 the purchase of land and buildings adjacent to the Harrison plant gave it a total area of two city blocks, together with two railroad sidings, docks, and other operating facilities. The Nopco Chemical Co. was incorporated at Harrison to enter the production of fine chemical specialties, and the Vitab Products Co., a California corporation, was acquired, making Nopco the sole American manufacturer of vitamin B complex from rice bran.

Nopco stock, which had been listed on the N. Y. Curb Exchange in 1936, was transferred to the N. Y. Stock Exchange in 1940. Shortly afterwards, a plant was built at Richmond, Calif., to provide additional facilities for fish-liver vitamin extraction, following which a New York corporation—Rare Chemicals, Inc.—was purchased from the Alien Property Custodian. At its plant in Flemington, N. J., this subsidiary manufactures anesthetics, physiological and nutritional deficiency correctives, and products related to the vitamin and hormone fields.

All during World War II, a substantial part of Nopco's manufacturing—including that of its subsidiaries—was directed toward the production of necessary materials for essential industries and prime government contractors.

Nopco personnel today numbers almost 1,000 persons. All officers have come up from the ranks and have been with Nopco for a considerable time. In addition to Charles P. Gulick, president and chairman of the board, these include in chronological order of association: vice-president G. Daniel Davis (sales, 1916), secretary Albert A. Vetter (accounting, 1919), treasurer Ralph Wechsler (chief chemist, 1921), vice-president Thomas A. Printon (sales, 1922), assistant secretary George H. Faux (credit manager, 1927), and vice-president Percy S. Brown (president, Brown Jeklin Co., 1933).

A dominant factor in Nopco's growth, the policy of technical research, has been consistently maintained. That it has paid its way is evident in the development of the many new products, which, in turn, opened the door to vast new industries. A far cry from its one product line of 1907, Nopco and its subsidiaries today manufacture over 2,000 items, which include sulfonated oils and synthetic organic chemicals for application in the textile, tanning, paper, grease, metal-working, paint and varnish, and allied industrial fields; also vitamins, fine chemical specialties, cosmetics, and ethical medicinals and pharmaceuticals.

NORTH AMERICAN RAYON CORPORATION was incorporated under Delaware laws, Apr. 29, 1927. It was organized by Vereinigte Glanzstoff Fabriken A.-G., a German rayon firm, which made its patents and processes for the production of viscose rayon and allied products available to the new company. Vereinigte in 1929 became a subsidiary of the rayon company Algemeene Kunstzijde Unie, N. V. of Holland. North American Rayon Corp. was originally incorporated as American Glanzstoff Corp., but the name was changed to the present one in 1934.

The original capital consisted of $7,000,000 of 7% preferred stock and 300,000 shares of common, and with the proceeds of this financing, the first unit of a plant was begun in 1927 and completed in 1928 at Elizabethton, Tenn., having a capacity of approximately 4,750,000 lb. of continuous-filament yarn per annum. In 1929 the demand for the product was so encouraging that 212,374 additional shares of common stock, Class B, were sold and a second unit was built to double the original capacity. Both units operate according to the bobbin-spinning method.

Prior to World War II the Company had developed a high-tenacity yarn for use in tires, of which small quantities were sold commercially. With the outbreak of hostilities and the cutting off of natural rubber supplies, rayon tire yarn became of strategic importance as the most satisfactory material in synthetic rubber tires. The Company immediately undertook to convert some of its textile yarn facilities to tire yarn production. Under a War Production Board directive, a third plant unit was completed in 1944, designed along the most modern lines for the manufacture of tire yarn by the pot-spinning method. The capacity of the plant reached 34,000,000 lb. per annum in 1947.

A modernization program for plant units I and II was begun in 1947, which includes an increase in annual capacity to 40,000,000 lb. It is expected to be completed late in 1948 or early in 1949. Since 1929 all plant additions and improvements have been made without recourse to outside financing. The American textile trade constitutes the market for the Company's output of apparel yarn, in addition to which high-tenacity yarn of heavy denier is sold to tire manufacturers. The Company also makes circular-knit cloth sold mostly to underwear manufacturers.

North American Rayon Corp. has the same board of directors and officers as American Bemberg Corp. The plants of both companies are adjacent and a number of departments are operated jointly. In Aug. 1947 the controlling stock interest held by Algemeene Kunstzijde Unie, N. V. and Vereinigte Glanzstoff Fabriken A.-G., its German affiliate, was vested by the Office of Alien Property agreement with the Netherland Government and Algemeene Kunstzijde. It is anticipated that the Office of Alien Property will eventually dispose of this controlling interest in this country.

NORWICH PHARMACAL COMPANY began in 1885, when Lafayette Moore, a Baptist minister in N. Y. City, became interested in his brother's laboratory work and after obtaining from him a pillmaking machine and some materials, moved to Norwich, N. Y., where he started making pills and selling them to physicians in the Chenango Valley. The young business, operating for a short time as Moore & Bell, became Norwich Pharmacal Co., Nov. 1887, active partners being Oscar G. Bell and Manley P. Green on the resignation of Lafayette Moore. Mar. 31, 1890, incorporation certificates were filed in New York State. Capitalization was $20,000, consisting of equal interests by each of the four first trustees: Bell, president; Cyrus B. Thomas, vice-president; Green, secretary; and Charles S. Norris, treasurer.

An ointment was first packaged in 1892 and marketed under the name Unguentine, which is today one of the Company's leading products. That year Robert D. Eaton, Norwich businessman, purchased for the Company the property now occupied on Eaton Ave., then known as Piano St. Eaton was one of the foremost leaders from a financial and managerial standpoint and served as an executive and director from 1900 until his death in 1933. His sons, Robert S. and Melvin C. Eaton, had joined the Company in 1906 and 1914, and have been active in its management since, now serving as chairman and president, respectively.

Purchase of the Amolin Co. in 1928 coincided with the Company's policy of specialization, which reduced the number of items from about 4,000 in 1918 to 160 in 1930 and 45 at the present time. Laboratory facilities were increased in 1939, initiating a research program which resulted in the introduction of Furacine Soluble Dressing, Lorophyn Jelly, and Lorophyn Suppositories to the ethical field. For the introduction of these products and for the distribution of other ethical items, Eaton Laboratories, Inc., a wholly owned subsidiary, was organized in 1945. During World War II, Norwich earned five Army-Navy awards for its production of protective ointments, laxatives, extracts, and drugs.

Leading Norwich specialties besides Unguentine, are Pepto Bismol, Zemacol, Unguentine Rectal Cones, Norforms, Respamol, Amolin Powder, Amolin Cream, Amolin Perspiration Stop, Ocusol, and Nordex. Capitalization is now $2,000,000, consisting of 800,000 shares of common stock at $2.50 par. Construction of a new manufacturing building and an additional office building in Norwich has just been completed (1948).

Present officers and directors are: Chairman, Robert S. Eaton; president, Melvin C. Eaton; executive vice-president, George W. Bengert; vice-presidents, Oliver W. Benedict, Thomas A. Brennan, Guy L. Marsters, and Howard A. Sumner; secretary and treasurer, John K. Hill; assistant secretary and assistant treasurer, John T. Horan. Directors are Robert S. and Melvin C. Eaton, John Alden, Benedict, Bengert, E. W. Collins, Duncan M. Copley, H. T. Hildebrandt, Marsters, Sumner, Otis A. Thompson, and John B. Turner. Officers and directors of the subsidiary Norwich Pharmacal Co., Ltd., of Canada are: M. C. Eaton, chairman and president; Bengert, vice-president; Hill, treasurer; Horan, secretary; Hildebrandt and Alden, directors. Officers and directors of Eaton Laboratories are: M. C. Eaton, president; Sumner, executive vice-president; Bengert, vice-president; Hill, treasurer; Horan, secretary; Alden and Dr. L. E. Daily, additional directors.

OHIO-APEX, INC., started out at the beginning of the depression, under the name Kavalco Products, to manufacture phenolphthalein, acetanilide, aluminum and zinc stearates, tricresyl and triphenyl phosphates and thiophosphates, phosphorus oxychloride and trichloride, etc. The Company was organized, Sept. 20, 1929, by William D. and Andrew A. Payne, prominent attorneys, and C. Olin North and Winfield Scott, well-known chemists and chemical engineers, with factory and offices at Nitro, W. Va. Their associates were Harold P. Roberts, chemical engineer; Dr. M. H. Hubacher, director of research; Charles O. Locke, chemist; and M. McMorrow, purchasing agent.

Through conditions over which the management had no control, the Company was dissolved in 1934 and a new one formed in Ohio under the name Apex Chemical Co. However, because other chemical companies were using the name "Apex" in their titles, the name of the Company was again changed in Mar. 1935 to Ohio-Apex, Inc. On Feb. 5, 1936, an accident occurred in the Company's laboratory and C. O. North, president and sales manager, was severely burned, dying on the same day. In April, Bernard H. Jacobson and Kenneth H. Klipstein purchased the ma-

jority of the stock in the Company from Mrs. North. In November, the Ohio corporation was dissolved and the present company incorporated in West Virginia.

Under Jacobson, continuously engaged in the manufacture of chemicals since his graduation from Lehigh University in 1917, the growth of Ohio-Apex has been rapid and many new products have been developed. The Company has pioneered processes based on Jacobson's patents for the manufacture of high-purity anhydrous aluminum chloride and today is the sole commercial producer of a white product of very low iron content. Ohio-Apex also pioneered the commercial manufacture of di-2-ethylhexyl phthalate, one of the most important plasticizers, and diallyl phthalate.

During World War II practically the whole production of Ohio-Apex went for essential military and civilian purposes, for which it was awarded four Army-Navy "E" citations.

Today Ohio-Apex is one of the largest chemical manufacturers in the world specializing primarily in plasticizers, which include a group of phthalate esters, Kronisol (dibutoxyethyl phthalate), Methox (dimethoxyethyl phthalate), Ethox (diethoxyethyl phthalate), Dinopol (di-n-octyl phthalate), dioctyl phthalate (di-2-ethylhexyl phthalate), di-Carbitol phthalate (bis-diethylene glycol monoethyl ether phthalate), KP-150 (fatty, phthalic acid esters), Adipol BCA (dibutoxyethyl adipate), and KP-201 (dicyclohexyl phthalate); a cyclic and noncyclic phosphate ester, Kronitex (tricresyl phosphate) and KP-140 (tributoxyethyl phosphate); and a group of fatty acid esters, KP-23 (butoxyethyl stearate), Kapsol (methoxyethyl oleate), and KP-120 (methoxyethyl acetyl ricinoleate). In addition, Ohio-Apex, manufactures phosphorus oxychloride, phosphorus trichloride, and anhydrous aluminum chloride.

A large portion of Ohio-Apex sales is made directly to manufacturers. However, a goodly part is through sales agents: Stoney-Mueller, Inc. (New York, New Jersey, Connecticut); Central Solvents & Chemicals Co. (Illinois); Wisconsin Solvents & Chemical Co. (Wisconsin); Western Solvents & Chemical Co. (eastern Michigan); Western Oil & Turpentine Co. (western Michigan); Griffin Chemical Co. (West Coast); Jos. Turner & Co. (phosphorus compounds).

The present officers of the Company are: Andrew A. Payne, president; John V. Ray, vice-president and secretary; Bernard H. Jacobson, vice-president and treasurer; Margaret M. McMorrow, assistant secretary; and E. W. Gum, auditor. The management has at all times conducted a full research program to improve its products and methods of production. Three separate laboratories are operated: for raw material and production control; for product research and applications testing; and for new products and development. Another modern laboratory is being erected. Cooperative research and outside consultants are regularly employed Recent programs have been with Dr. Benjamin T. Brooks, New York; the Battelle Memorial Institute, Columbus; Dr. Robert Steckler, Cleveland; and Foster D. Snell, Inc., Brooklyn, N. Y. The present plant covers about 20 acres and employs 250-300.

OLDBURY ELECTRO-CHEMICAL COMPANY was incorporated, Nov. 1896, for the purpose of manufacturing chemicals. It built a plant at Niagara Falls, N. Y., and commenced manufacturing phosphorus by the electric-furnace method in Sept. 1897, using hydroelectric power from the Niagara Falls Power Co. In 1899 the Company added the manufacture of chlorates, continuing the production of sodium chlorate only from 1903 on for several years. In 1909 it commenced the manufacture of potassium perchlorate and in 1910, the manufacture of red phosphorus and phosphorus sulfides.

During World War I, Oldbury was the principal supplier of yellow phosphorus to the Chemical Warfare Service and also built and operated a phosgene plant for it. In 1920 the Company began manufacturing oxalic acid. In 1927, with the acquisition of the Phosphorus Compounds Co., an associated company, it entered the manufacture of hypophosphites, phosphoric acid, phosphoric anhydride, and phosphorus chlorides. Production of potassium chlorate was resumed in 1933. In more recent years other phosphorus compounds have been added and also the manufacture of perchloric acid.

The head office and works are at Niagara Falls, N. Y., with branch offices at 19 Rector St., N. Y. City. The first president of the Company was John J. Riker of New York, who was succeeded in 1923 by F. A. Lidbury of Niagara Falls, head until Jan. 30, 1947. The present officers are: Walter Wallace, president and treasurer; Dr. Earl L. Whitford, vice-president and assistant treasurer; Dr. M. B. Geiger, secretary; and A. T. Hinckley, assistant secretary.

ONYX OIL & CHEMICAL COMPANY went into production under the name of the Richards Chemical Co., which is today the Research & Production Division of the Company, with the idea of filling a need for finishing oils made under much more strict chemical control than was then the custom and applying research toward developing new processing materials for many other textiles beside silk. This was the idea of two young technical men with considerable practical experience in the finishing of textiles and the application of processing oils for silk. Victor H. Berman, primarily a field man who knew silk-finishing methods and the objectives of treatments, undertook the introduction of the new company's products in the mills. Richard Von Oesen, familiar with finishing, but also a production man, took care of making the new finishing products contemplated. Manufacture began on the first floor rented in a building on Warren St., Jersey City, N. J.

The new business prospered with its few technically controlled silk-finishing oils and within three years had purchased the building on Warren St. In 1915 adjacent property damaged by an explosion was bought and considerable expansion in production capacity took place. At this period, the first research laboratory of the Company was established as a separate entity.

Between 1916-21 pioneering work was done on sulfonated oils for textile finishing. Philip Kaplan, a young chemist who had joined the Company in 1910 and is today vice-president in charge of production, had much to do with the establishment of manufacturing methods which enabled Onyx to assume a leading position in textile finishing.

In 1922, after ten years of research, Onyx began to produce sulfonated oils. These potent new products offered hitherto unavailable standards of penetration and softening action, and paved the way for the development of a large number of derived and related materials which have done so much to improve textile-finishing operations since. The printing gums, warp sizes, and silk-throwing oils, developed in 1924-25, soon required a special division. By 1929 Onyx had developed specialized finishes for rayon and a new line of hosiery finishes.

Two products worked out in the depression years are still doing an outstanding job in the industry: naphthalenesulfonic acid ester, a powerful penetrant combining the action of a dispersing agent, emulsifier, and colloidal film-breaker; and Phi-O-Sol, a sulfated ester of a fatty acid, one of the most powerful wetting agents known. Also during the depression, Onyx developed a new, "soapless" shampoo which rated a new division. Today the Richards Sales Corp. markets perfumes, bath powders, face powders, shampoos, and cold creams made by the Company.

In 1933 Dr. Hugh H. Mosher joined the Company to begin nearly 15 years of brilliant research which has contributed materially to improved textile processing. The same year a Chicago sales agency was established and a Canadian plant built at St. Johns, Quebec, with sales offices in Toronto and Montreal.

Up to the outbreak of World War II. Onyx research had developed the Mapro series of sulfated higher fatty alcohols; the water repellents, Repellotex D3 and D4; the Onyxsans, cation-active softening agents, first produced in 1938; and the first Onyx NCF urea-formaldehyde resin finishes, in 1939, for the creaseproofing and shrinkproofing of textiles.

With the coming of war, Onyx was faced with the many problems growing out of the need for special textile finishes to meet conditions on many battle fronts. The most far-reaching result of Onyx research has been the development of a wide line of surface-active materials with application possibilities in textiles and other industries, which have only just begun to be explored. Aurinol and Neutronyx are two typical examples. In 1942 Onyx developed for the Navy alkyldimethylbenzylammonium chloride, which today is revolutionizing sanitation practice because of its nontoxic bactericidal and bacteriostatic action.

Late in 1945, Dr. Reginald L. Wakeman joined the staff, after postdoctorate studies in Paris and Zurich and 10 years of research in synthetic resins and plastics, to direct research for the Company. The outstanding product development for 1946 is Eternalure D-45, a one-treatment. water-dispersed resin finish for nylon hose.

Other Company divisions include the Export Division, established in 1935, to serve world markets through Onyx-supervised agencies and the Industrial Division, formed in 1942 to promote and develop uses for quaternary ammonium compounds, and other products hitherto sold primarily in the textile fields. A new plant added in 1946 is located on Staten Island and will for the present produce NSAE, resin compounds, and quaternaries.

The Onyx Oil & Chemical Co. is today a well-integrated organization with modern equipment, unusually complete research facilities, and a far-reaching research program, plus a Sales Department which is primarily a technical service force. Under Albert R. Jenny, sales manager, and Leon P. Brick, vice-president in charge of sales, sales and service offices with warehouse facilities are located in Chicago, Providence, Charlotte, and Atlanta.

ORONITE CHEMICAL COMPANY, Standard of California subsidiary charged with the development and marketing of chemical products, had a heritage of 30 years' experience when it was formed in 1943. That heritage dated back to 1912, when lamp oils were of greater importance than gasoline, and chemicals were of very minor interest to Standard of California. In the period 1912-27, methods for recovery of SO_3 and sulfuric acid for re-use in acid treating were introduced to Standard's refining operations and became the Company's first important chemical developments.

In 1912 petroleum refining involved simple fractionation, together with sulfuric acid and caustic treatment. Only a few petroleum chemicals were recovered even in crude form. The principal chemical requirements in petroleum refining being sulfuric acid, SO_3, and caustic soda, Standard's research was directed toward more efficient utilization of these materials.

One of the earliest methods for producing nonsmoking lamp oils involved treating the crude oil with SO_3. In 1912 a process was installed for recovering SO_2 from the sulfuric acid sludge left, by retorting, converting the SO_2 over a platinum catalyst to SO_3, and recycling this. By-products of the retorting were coke and a

highly aromatic oil which was marketed as a paint thinner. At about the same time, a process was installed for atmospheric hydrolysis of other sulfuric acid sludges. This yielded weak sulfuric acid which was concentrated by open-pan evaporation for re-use in various acid-treating operations. The process was patented by Standard of California in the early 1920's and is still in use.

For a brief period starting in 1915, aromatic hydrocarbons including benzene, toluene, xylenes, and a heavy solvent oil were produced by severe thermal cracking of a distillate from Coalinga crude oil. Wartime need for coal-tar hydrocarbons was responsible for development of processes of this type, but because of their high cost they were abandoned at the end of World War I. Nitrobenzene was also produced on a small scale at the Richmond refinery during the war.

At about this time, the first naphthenic acid derivative was produced commercially at Richmond. The caustic wash from lamp-oil treating was acidified to crude naphthenic acids which were purified and converted to the aluminum salt. Aluminum naphthenate proved useful in making thickened lubricating oils, competing with castor oil. Lead oleonaphthenate was manufactured during the early 1920's for similar use. Medicinal-grade mineral oils have been manufactured commercially by Standard of California since 1915 and crude by-product sulfonates since the early 1920's. In 1941 facilities were installed for manufacturing purified sulfonates and their use thereby extended to wetting agents, emulsifiers, and rust-preventive compounds, besides fat-splitting.

By the mid-1920's, a research was on to develop solvent chemical derivatives from cracked gases and purification methods and applications for by-product chemicals. The anticipated markets were primarily among chemical-consuming industries. The solvents program was undertaken about 1928. By 1931 a patent position had been attained and commercial processes for isopropyl, sec.-butyl, and tert.-butyl alcohols were under consideration. However, because of the distressing economic conditions, the project was tabled. In 1935 polybutene became Standard's first synthetic chemical product to be marketed among chemical-consuming industries. Also in 1935, Standard pioneered the production of heavy-duty Diesel oils compounded of typical chemical products. Here Standard clearly made the first and most important contributions.

Meanwhile, in this period, 1927-41, numerous developments were being made in the by-product chemical field. With the advent of odorless natural gas in the late 1920's for household and industrial use, a demand arose for a warning odorant. Calodorant, composed of organic sulfides, was introduced commercially in 1927 for this purpose. At present it constitutes about three-fourths of the total odorant requirements for natural gas in the United States. Similar sulfur compounds provided the base stock for the alcohol denaturants, Ethatate and Agdite, which sold in large quantities in the 1930's.

Commercial manufacture of naphthenic acids and derivatives by Standard of California started in 1931 and the market for heavy metal naphthenate paint, varnish, and ink driers in the United States expanded rapidly thereafter. Facilities for commercial-scale recovery of several grades of cresylic acids from cracked naphthas were installed at the Richmond refinery in 1937. Commercial manufacture of mixed aliphatic acids from lighter cracked naphtha fractions was begun in 1938. Research on nitrogen bases was first undertaken in 1932. These alkyl pyridines are recoverable by acid extraction of cracked naphthas and may be hydrogenated catalytically to the corresponding alkyl piperidines. In 1941 Standard of California introduced an ultraspeed rubber accelerator derived from nitrogen bases, but because of the acute shortage of rubber in 1942 and the sharp drop in

demand for accelerators, conditions were unfavorable for sales development, so manufacture was dropped.

Commercial manufacture of by-product hydrogen sulfide was undertaken at the El Segundo refinery with the installation of a Koppers' phenolate unit in 1936. Later the unit was converted to the Girbotol process. Hydrogen sulfide is sold to the General Chemical Co. which operates an adjacent sulfuric acid plant.

A source of relatively large amounts of low molecular weight, mixed mercaptans became available to Standard of California in 1939. These mixtures may be separated into individual mercaptans from methyl through butyl, in purities of 95-98%. In the past, mercaptans have been available only in relatively small quantities at correspondingly high cost. Petroleum provides a cheaper source for pure mercaptans, which should stimulate new uses.

Developments prior to World War II in the petroleum industry and the war-inspired demands for chemicals brought the industry in general toward a new era in the chemical field by 1941. The development of catalytic refining and superfractionation processes during the 1930's and their installation in the early war years made available new raw materials processes and technical background, all of which added greatly to the ability of the industry to compete in the chemical field. Mounting demands for chemicals also made the field more attractive to the petroleum industry, which by long experience was accustomed to large-scale, low-cost operations. For Standard of California there were further specific incentives. Successful technical developments in the solvent field during the early 1930's provided an extensive technical and patent position which it was thought might fit into the wartime solvents picture. Successful progress in the development and marketing of by-product chemicals had demonstrated that chemical markets were an attractive outlet for petroleum-derived products. Finally, the location of Standard's refineries on the West Coast, in the heart of rapidly growing industrial areas, favored its competitive position with respect to those local chemical markets.

In 1941 the Research & Development Department undertook an expanded program strictly on chemicals. In 1943 the Oronite Chemical Co. was formed as a wholly owned subsidiary to handle development and sales of chemical products. Recognition of the increasing importance of chemicals was further indicated by the formation, in 1944, of a separate Chemical Division in Standard's Manufacturing Department and likewise in another wholly owned subsidiary, the California Research Corp. The latter's Chemical Division carries out an extensive research program entirely for Oronite.

In the pure hydrocarbons field, a government-owned butadiene plant was installed at El Segundo in 1944. Like butadiene, toluene, whose modern production was started at Richmond in 1944, was sold directly to the Government. However, because of the flexibility designed into the plant, the unit is capable of producing xylenes and other higher aromatics as the chief products or as by-products of other operations. Oronite has taken the lead in development of markets for these higher aromatics and California Research Corp. has, since 1944, developed processes for the three xylene isomers in purities as high as 95%. *o*-Xylene of 90% purity has been produced commercially since 1945 and projects on 95% pure *o*-, *m*-, and *p*-xylenes are currently in process and market development stages. The catalyst for the toluene plant has been produced since 1943 at Richmond in a separate plant. It has proved so successful that it is being used in seven of the eight petroleum toluene plants in the United States, with Oronite handling the sales.

Manufacture of Napalm from naphthenic acids for the Chemical Warfare Service was another important wartime contribution of Standard of California and Oronite. The demand for naphthenic acids in copper naphthenate for fungicides

and in Napalm largely eliminated naphthenate driers. Oronite was a leading supplier from 1943 until peace, when normal production of driers was resumed.

Utilizing 90% *o*-xylene as charging stock and based on a process developed by California Research Corp., a plant for phthalic anhydride manufacture was installed at Richmond in 1944-45. This is the first unit utilizing other than coal-tar raw material, the first phthalic anhydride plant west of St. Louis, and Oronite's first large-scale synthetic chemical development. Oronite's most recent contribution in the chemical field is an alkylarylsulfonate-type detergent, announced in Sept. 1946.

The officers and directors of Oronite are: George L. Parkhurst, president; Milton L. Baker and Gaynor H. Langsdorf, vice-presidents; Thomas G. Hughes, secretary-treasurer. On July 1, 1948, executive offices were established in new, larger quarters at 38 Sansome St., San Francisco.

PACIFIC COAST BORAX COMPANY dates back three-quarters of a century to the year 1872. The borax industry in the United States was just eight years old, the sole source of supply being the waters and mud of certain lakes in Lake Co., Calif., in which borax had been discovered in 1856. The price of the product was still excessively high, its uses relatively few.

Then in 1871, "cottonballs" (ulexite) were discovered on a dry lake bed in Esmeralda Co., Nev., which yielded pure borax, the first to be produced in Nevada. Within a few months this region, known as Columbus Marsh, was covered with claims, and plants were set up alongside to refine cottonballs. With quantity fuel needed for the boilers scarce on the desert, an enterprising young man who worked his way westward following mining camps, saw his opportunity. He bought a wood ranch and arranged to supply fuel to William T. Coleman of San Francisco, who had gone into the borax business at Columbus. The young man's name was Francis Marion Smith, later to become known as "Borax" Smith, the outstanding figure of the borax industry in the United States.

Two years later Smith discovered rich borax deposits on Teels Marsh, a few miles from Columbus. With his brother, Julius P. Smith, he organized Smith Bros. with Chicago capital and started production. They were soon followed by at least 100 other prospectors whose claims they bought up one by one until they were sole owners of the entire Teels Marsh deposit. F. M. Smith later bought out his brother's interest and Smith Bros. became the Teels Marsh Borax Co., with F. M. Smith as president. The product was marketed through William T. Coleman & Co. of San Francisco, which was operating at Columbus Marsh. Smith himself soon thereafter acquired borax holdings at Columbus and formed the Pacific Borax Soda & Salt Co.

Around 1880 cottonballs were discovered in Death Valley, Calif., by Aaron Winters. Coleman bought up these claims for $20,000 and organized the Harmony Borax Mining Co. By 1882, when this company was ready for production, Coleman acquired another borax deposit located east of Death Valley. The great problem in operating these two rich deposits was transportation. The nearest railroad station was Mojave, 165 miles from Death Valley, across a formidable mountain range and over desolate, almost waterless desert. The problem was solved by the now-famous 20 Mule Teams which consisted of 20 animals, hitched in pairs and controlled by a single jerk-line 120 feet long. There were two wagons to each outfit—said to be the largest wagons in the world—designed by J. S. W. Perry (later superintendent of the Pacific Coast Borax Co.'s mines in the Calico Mts.) and built by J. T. Delamater. Each wagon had a capacity of 24,000 lb. A water tank coupled onto the rear wagon. The round trip from Death Valley to Mojave took 20 days.

Up to this time it had been believed that commercial borax occurred only as cottonballs, or encrustations on lake beds, or as tincal (crude borax). But in 1882, desert rats prospecting in the mountains of Death Valley found a hard, glittering, white substance with the surface appearance of quartz. Analyses proved it to be borate of lime with a far higher boric acid content than cottonballs. The new mineral was named colemanite, after William T. Coleman, who acquired the claims on which the discovery had been made and other colemanite claims soon located in the region. One of the largest deposits was named Lila C, in honor of Lila C. Coleman. At about the same time, down in the Calico Mts. to the south where a silver boom was in progress, two prospectors found an outcropping of a crystal-like ore which proved to be high-grade colemanite as rich as that from Death Valley and only eight miles from the main-line railroad.

From now on the borax industry was faced with a real quartz-mining proposition. No longer would men simply shovel the stuff from the surface of dry lake beds. F. M. Smith, whose two operations were supplying almost a third of all the borax on the market, joined forces with Coleman, who had title to the Calico claims. They purchased a plant at Alameda for a refinery and by 1888 were ready for large-scale production. But that same year Coleman, whose business interests were many, was forced into bankruptcy. Smith got Calico Mine, the Harmony and Amargosa works, and various undeveloped colemanite deposits in Death Valley. Because of their remoteness, the Harmony and Amargosa works were closed down at this time, but the 20 Mule Team remained. It continued to haul borax from the mine at Borate, until the Borate Daggett Railway was extended to the mine.

In 1890 Smith consolidated his borax properties in the Pacific Coast Borax Co. Six years later he went abroad and effected an amalgamation with Redwood & Sons, English chemical manufacturers and at that time the largest European buyers of borax and boric acid. The new company, the Pacific Borax & Redwood's Chemical Works, Ltd., in 1899 became Borax Consolidated, Ltd., with Pacific Coast Borax directing all its U. S. operations and Smith in control. In 1897 Smith made arrangements for the construction of a new refinery at Bayonne, N. J., which went into operation in 1899. The Alameda plant in 1898 began to manufacture boric acid besides borax.

By 1904 the ore in the Calico district (Borate) was running out, so mining operations were shifted to the Lila C Mine, the ore being hauled 39 miles by 20 Mule Team to the railroad station at Zabriskie, named for the vice-president and general manager of the Pacific Coast Borax Co. The Lila C was operated for seven years until it began to show signs of exhaustion in 1914. The next deposit to be tapped was the Biddy McCarthy, located in 1883 in the Funeral Mts. overlooking Death Valley. The new camp, Ryan, was named after John Ryan, general superintendent of the Pacific Coast Borax Co. and associated with Smith from his earliest days in the borax business. It was about this time, 1913, that F. M. Smith met with serious financial reverses and his holdings in the borax company had to be sold.

For another 12 years the group of mines at Ryan produced practically the entire output of the Pacific Coast Borax Co., and would probably have continued many more, had not a new discovery been made in the summer of 1926, in the desert near Kramer, Kern Co. The Pacific Coast Borax Co. already had undeveloped colemanite claims here, but this new ore was a form of borax never before encountered—a borate of sodium known as kernite or rasorite, after C. M. Rasor, field engineer of the Company. The richness of the new ore, the low cost of treating it, and the accessibility of the deposits to the main-line railroad, changed the

whole picture. Colemanite mining came to an end. Ryan mines were closed down and operations transferred to the new locality, Boron.

Today practically the entire output of the Pacific Coast Borax Co. is from the mine at Boron. The ore is refined at the Company's plant in Wilmington, Calif., built in 1923, taking the place of the Alameda plant and ultimately, of the Bayonne plant. The Company has seen what was once a scarce and almost prohibitively expensive product become a common commodity costing only a few cents a pound. It has seen borax uses increase year by year in industry, in agriculture, in medicine, in the home. The history of the Pacific Coast Borax Co. is the history of our West—of pioneers who had the vision, the courage, and the energy to conquer a wilderness—and their successors, who today still carry on the work of developing new and untapped resources in the desert to bring a needed product to the markets of the world.

PARKE, DAVIS & COMPANY was born in a drugstore, Oct. 26, 1866, as the partnership Duffield, Parke & Co. In 1862 Dr. Samuel P. Duffield, physician and pharmacist, had begun a small manufacturing business in a drugstore he had founded in Detroit, following postgraduate study in chemistry abroad. Here he manufactured "Ether, Sweet Spirit of Nitre, Oil of Wine, Hoffman's Anodyne, and Blue Pill Mass." During the next four years his first partner was A. L Patrick, who invested $10,000 in the business; his second, Francis C. Conant, who purchased Patrick's interest. When Conant became dissatisfied with the halting progress of the new venture, Hervey C. Parke of Michigan, who had recently sold out a successful mining hardware business, bought his interest.

The following year, 1867, George S. Davis came into the firm, bringing experience acquired in the wholesale drug business. Two years later Dr. Duffield retired and Dr. A. F. Jennings took his place, the firm becoming Parke, Jennings & Co. in 1869. Dr. Jennings took charge of the manufacturing for two years, when he also left the partnership and the business assumed its final name of Parke, Davis & Co. on Nov. 16, 1871. Associated with Parke and Davis as "special partners" were W. H. Stevens and John H. Grout who each contributed $10,000 to the firm.

During these nine years the young business faced manifold financial difficulties. It grew slowly, but gradually a surplus was realized which went into increased manufacturing facilities. A small, new laboratory was built on the site of the present main laboratory buildings, just at the time of the panic of 1873. The firm weathered this depression and two years later incorporated as Parke, Davis & Co., with a paid-in capital of $81,950. At the close of 1876 the books showed a profit for the first time and in 1877 a dividend was declared which has been paid every year since that date. The founders of Parke, Davis & Co. knew well that the safe progress of their venture depended on sound and enduring principles. They early adopted the watchwords "Purity, Accuracy, Reliability" for their products.

In 1869 the first feeble steps were taken toward medicinal research. At that time the production of new medicinals meant only one thing: the discovery and development of previously unknown or unused vegetable drugs. Every new plant heard of in the United States or some foreign country or suggested by a physician or publication was investigated at once and if it promised to be valuable, supplies were obtained and the fluidextract prepared for distribution to physicans. "Working Bulletins" detailing information regarding the botanical character and medicinal properties of such new drugs were prepared for physicians and other scientific men. In the course of these investigations Parke, Davis & Co. representatives explored British Columbia, Washington, Oregon, Northern California, and Mexico. Count

Hansen was sent to the Fiji Islands, another explorer to the West Indies, and still others to South America. In 1885 Dr. Henry H. Rusby made an extensive botanical exploration in South America for Parke, Davis.

From these investigations nearly 50 new drugs were added to our materia medica. Despite rapid abandonment of plant drugs during the last 20 years in favor of newer and more potent and specific medicaments, nine of these still remain in the latest editions of the U.S.P. and N.F. The most important, cascara sagrada, was introduced in 1877; *Viburnum prunifolium,* 1869; yerba santa, 1876; areca nuts, 1878; and saw palmetto, 1879. Another result of the investigation was the accumulation of an extensive herbarium and a fine botanical library which were eventually given to the Botany Department of the University of Michigan.

Closely associated with the introduction of new remedies was the dissemination of information concerning them, so from occasional bulletins there gradually developed a series of publications. A Publication Department was organized and journals dealing with pharmacy, therapeutics, and surgery began to be published. Parke, Davis & Co. was responsible for preserving the existence of one of the outstanding publications of American medicine, the *Index Medicus.* This was started in 1879, with Dr. J. S. Billings of the U. S. Army as editor and F. Leypoldt of New York as publisher. It was being published at a considerable loss and on Leypoldt's death in 1884 its discontinuation was announced. After three months' intermission it was taken over by George S. Davis, representing the Publication Department of Parke, Davis, brought up to date in the first issue of 1885, and continued under these auspices until Apr. 1895. It was then taken over by the editors and in 1903 was placed in the hands of the Carnegie Institute. In 1894 *Therapeutic Notes,* a medical journal summarizing developments in medicine, was begun and is Parke, Davis & Co.'s oldest continuous publication.

The year 1879 marks the beginning of one of the Company's greatest contributions to medicine and pharmacy. Before this fluidextracts, tinctures, and extracts of many potent vegetable drugs, as well as the drugs themselves, had varied in strength from valueless to dangerously potent, without anyone knowing the difference until they were actually used on a patient. Weight of the drug or measure of the fluidextract were the sole criteria of strength. In Sept. 1879 for the first time a liquid drug preparation was offered which had been adjusted to a uniform standard by means of a chemical assay. This *Liquor ergotae purificatus* was the first "standardized" medicinal preparation. The method of assay was very crude but it was the beginning of a new era in medicinal products. By 1883 preparations of 20 other drugs were so being standardized. The idea met strong opposition at first but gradually gained wide application. It was not until many years later, however, that assays and standardization procedures received official recognition in the U. S. Pharmacopoeia.

In 1897 a series of drug products standardized by physiological methods was offered to the physicians. This was the beginning of physiological standardization now so widely applied to a great variety of products. Dr. A. B. Lyons was responsible for the development of these chemical assays and Dr. E. M. Houghton for the physiological.

In 1901 the firm established the first organized and systematic procedure for subjecting medicinal agents to clinical proof before marketing. This evolved into the Department of Clinical Investigation and 38 years later became a legal requirement for new drugs under the Food, Drug & Cosmetic Act.

The commercial beginning of what is commonly known as biological work was in 1894. Stimulated by the publication of a series of European researches, Parke, Davis & Co. in this year established a small department for pharmacological work

and the production of diphtheria antitoxin. This was followed in 1897 by antistreptococcic serum and antitetanus serum. When in 1903 the first federal law controlling the manufacture and sale of serums, antitoxins, etc., was enacted, Parke, Davis & Co. received, and still holds, license No. 1. Bacterial vaccines were first commercially prepared in 1907 pursuant to the original work of Sir A. E. Wright. From these developed various related products, including immunogens. By 1908 the animal requirements for biological work had so greatly increased, it became necessary to establish a biological farm at Rochester, Mich.

When George S. Davis retired from the Company in 1896 and two years later Parke died, a reorganization took place and three prominent Detroit business men, David Whitney, Theodore D. Buhl, and Henry Stephens, took over Davis' interest. Buhl became president and William M. Warren, general manager. On Warren's untimely death in 1903, Ernest G. Swift became general manager. The year 1907 saw the death of president Buhl and his succession by Frank G. Ryan, who came into the organization in 1900, with 15 years' experience in the drug business and on the teaching staff of the Philadelphia College of Pharmacy.

In 1902 a new laboratory was completed, which was the outstanding industrial research laboratory of the time, with portions of it devoted to biological research. An addition was built in 1941 and the old laboratories remodeled to give more than twice the original space.

As interest in vegetable drugs waned, increased attention was given to animal glands. The first of these to be supplied commercially was desiccated thyroid in 1893. Two years later a dried and powdered form of the suprarenals was marketed. Intensive research by many laboratories culminated in the isolation of the first pure endocrine hormone, adrenalin, by Takamine in 1900 and the establishment of its chemical formula by Aldrich shortly thereafter, both of the Parke, Davis & Co. laboratories.

In 1909 the first active extract of the posterior lobe of the pituitary ever supplied commercially was offered under the name Pituitrin. Continued research resulted in the separation by Oliver Kamm and his associates of the two active principles in the posterior lobe, in 1927, and their preparation as medicinal solutions under the names of Pitocin (α-hypophamine) and Pitressin (β-hypophamine). Investigations of the anterior pituitary brought the introduction in 1919 of Antuitrin, a product later discarded in favor of more active and specific hormone preparations, particularly Antuitrin-S, first supplied in 1932. Intensive research of numerous other hormones and hormone-containing materials have led to Theelin (estrone) in 1930, Theelol (estriol) in 1932, Paroidin (parathyroid extract) in 1927, Eschatin (suprarenal cortex extract) in 1931, etc.

A definite research program on vitamins was begun in Sept. 1916, leading to the first biological assay of cod liver oil for vitamin D; the cooperative development of an official vitamin A assay; the first label statement in units of vitamins A and D; the first published recognition of more than one component in vitamin B; cooperation in the work which culminated in the isolation of crystalline vitamin K; and recently the preparation of crystalline antianemic vitamin B_c.

Typical of more recent advances in chemical research and illustrative of the scope of Parke, Davis clinical investigations are the medicaments: Mapharsen (oxophenarsine hydrochloride) for syphilis, introduced in 1935; Dilantin (diphenylhydantoin) for epilepsy, 1938; Promin for leprosy, 1944; Benadryl for various allergies, 1946. From biological research have recently come thrombin, a blood coagulant for use in surgery, and the large-scale production of influenza virus vaccine; from the new and rapidly expanding research of penicillin, streptomycin, and other antibiotics.

For nearly 50 years Parke, Davis & Co. has from time to time established fellowships in various universities and colleges; cooperated with research groups in other institutions on medical subjects; contributed to the scientific development of the U. S. Pharmacopoeia and National Formulary.

Five of its staff have been members of the U.S.P. Revision Committee: Dr. E. M. Houghton, pioneer in physiological standardization; Dr. Wilbur L. Scoville, noted pharmaceutical authority; Dr Oliver A. Farwell, botanist; Dr. J. M. Francis, chief chemist, 1905-24; and Dr. Frank O. Taylor, chief chemist, 1924-45. Other staff members of national or international reputation include Dr. Charles T. McClintock, first director of the Research Laboratories; Dr. Jokichi Takamine, discoverer of adrenalin; Dr. Oliver Kamm, present scientific director; and Dr. Elwood A. Sharp, director of clinical investigation and authority on anemia. The beginning of the Company's expansion from a single small laboratory in Detroit to its present world-wide scope was a branch in N. Y. City in Feb. 1881. Small manufacturing operations were begun in Canada at Windsor, Ontario, in 1887 and a full-scale laboratory established there in Jan. 1891, which later expanded greatly. Looking West, a branch was opened in Kansas City in June 1890, coincident with the erection of a large addition to the plant in Detroit. A branch was established in London in 1891 and after developing some manufacturing work there during the next 10 years, a considerable laboratory was built at Hounslow, England, in 1902, which also greatly increased during the succeeding years. From London as a base, advance was made into other European countries, South Africa, Egypt, and the Near East. In 1899 a branch was opened at Simla in eastern India, which was transferred in 1907 to Bombay. During these same years domestic branches were opened at Baltimore, 1897; New Orleans and Montreal, 1898; Chicago and St. Louis, 1901.

With a vision of the future development of Australia, a branch was established in Sydney in 1902. Manufacturing was begun in 1912 and a separate laboratory built in 1917, which has been gradually much enlarged. Meanwhile further extension was projected in South and Central America, Mexico, and the West Indies. Toward the Far East entrance was made into China and the Philippines. This business so increased that in 1915 manufacturing was begun in Havana and Buenos Aires; in 1925, in Rio de Janeiro. A new laboratory has recently been built in Mexico; before World War II some manufacturing was done in Shanghai. The early stable development of this foreign business was largely under the direction of Oscar W. Smith, later to become president. The direction of the more recent expansions here and abroad has been chiefly in the hands of Ernest Brier, present vice-president.

In 1931 the firm purchased the Bay Co. of Bridgeport, Conn., one of the three largest producers of surgical dressings. This plant and one at Versailles, Conn., have been further developed as integral parts of Parke, Davis & Co.

There are today more than 21,000 stockholders in the Corporation, many of them employees. During its lifetime 1,350 persons have been in active work for 25 years or more, and over 800 of these are still active. Practically all men in key positions worked up from a minor position, and in 80 years there have been only six presidents: Hervey C. Parke from its founding to 1898; Theodore D. Buhl until 1907; Frank G. Ryan, until 1920; James E. Bartlett until 1921; Oscar W. Smith to 1938; Dr. A. W. Lescohier, current president. Norman H. F. McLeod retired in 1947 as vice-president and treasurer (1921-46) and chairman of the finance committee.

The present (1948) officers and directors are: Dr. A. W. Lescohier, president; Cleveland Thurber and Nathan T. Viger, vice-presidents; Homer C. Fritsch, vice-

president and general manager; Harry J. Loynd, vice-president in charge of domestic and Canadian sales; E. Brier, vice-president in charge of foreign operations; Lawrence D. Buhl, John B. Ford, Jr., H. L. Pierson, directors; K. D. McGregor, secretary; and D. E. Mitchelson, treasurer.

PATENT CHEMICALS, INC., grew out of the adversities of the years 1928-32 when many chemical manufacturing companies which had their inception in the disturbances of the World War I, got into difficulties due to overproduction, price cutting, and inefficient production, as well as low consumption. One of the fatalities was the Chemical Company of America of Springfield, N. J., of which Dr. Samuel Isermann was president and J. W. Orelup, chief chemist. After receivership failed to revive the Company, Isermann and Orelup, not wanting to see the results of their work lost, organized Patent Chemicals, Inc., and Synthetic Chemicals, Inc. Orelup's work in introducing anthraquinone colors was to bear fruit in a new field, the petroleum industry. Ethyl gas was in its infancy and various additives were introduced. Color was needed to identify these products to the consumer and the anthraquinone color bases were the answer. Patents were obtained covering the uses of these colors in gasoline and other petroleum fields.

Among the synthetic chemicals, wetting agents, detergents, and emulsifiers were becoming important and today these synthetic surface-active compounds have created an entirely new industry. Synthetic Chemicals, Inc., introduced the alkylated naphthalenesulfonic acids under the Tensol name and the sulfated fatty acid condensate products under the Intramine trade-mark.

Expansion of Patent Chemicals, Inc., continued through production and synthesis of special oil-soluble dyes for the petroleum industry, finding new fields for these colors in the plastics industry, and also introducing new pigment colors and textile dyes stemming from the acid alizarin series. Synthetic Chemicals, Inc., continued to expand its line of emulsifiers, rust inhibitors, and the various ramifications of the surface-active compound field. A serious fire at the Jersey City plant forced a long-needed change in location with expanded facilities to a new plant at Paterson, N. J.

S. B. PENICK & COMPANY has made continuous progress in botanical drugs and medicinal chemicals over a period of 33 years, and has helped keep American drugstores stocked with some 7,000 items. Through wars, depressions, and periods of prosperity, it has accepted the challenge of changing conditions; been unrelenting in efforts to improve the quality of raw drug materials; developed new and improved species of drug plants; provided an uninterrupted supply of raw and manufactured materials of botanical origin. Established in May 1914, by Sydnor Barksdale Penick, Sr., the Company has grown from an humble plant of three employees. Then, aside from collectors who gathered hundreds of botanicals from near-by fields and woods, the work was done by Troyl B. Dysart, present manager of the Asheville plant, and Sydnor B. Penick, Sr., chairman of the board. Today, the Company has five manufacturing plants, a research laboratory in Jersey City staffed by 30 workers, and a total of 700 employees. Besides the chairman, its officers include: Sydnor B. Penick, Jr., president and general manager; Albert D. Penick, vice-president of production; Dr. Thomas Lewis, vice-president and technical director of Manufacturing Department sales; Harold Meyer, vice-president; Miss M. E. T. Corr, vice-president of import purchases; J. T. B. Bullwinkel, vice-president; Charles W. Speed, treasurer; James G. Flanagan, secretary and general counsel.

Sydnor B. Penick, Sr., began operations in a small brick building in Marion,

N. C. Capitalizing his cumulative experience in various drug houses, Penick, Sr., reasoned that it would be more feasible to sell milled drugs in packages instead of roots, herbs, and leaves in burlap bags—as was the customary practice at that time. With the outbreak of World War I, three months after the inception of the Company, the need for botanical drugs became so great that new drug sources were required. It was therefore necessary to open a New York office and within six months it was doing ten times the Marion business. In those days of scarcity, the Company provided service to the drug trade far beyond its limited physical facilities, and in 1917 the original establishment moved from Marion to Asheville, N. C., center of the drug collection district.

In 1919 the New York plant was transferred to Jersey City, where a four-story building for storage, milling, manufacturing, shipping, and receiving had been purchased. This was outgrown within a year and adjoining property added. In 1921 New York offices were established at 115 Fulton St. The following year the Company acquired the Crude Drug Department of Smith, Kline & French of Philadelphia, and the Jersey City plant moved to a larger building in Weehawken. In 1925 S. B. Penick & Co. purchased the 27-year-old crude drug business of P. E. Anderson Corp., New York, and in 1930 a drug-gathering station at Roan Mountain, Tenn., was added to Asheville's work.

During the depression of the thirties, Penick launched an all-out expansion program and bought five competing houses. In 1931 the 75-year-old crude drug firm of R. Hillier's Son Corp., New York, and J. Q. McGuire & Co., a botanical-collecting firm at Asheville, were acquired. R. V. H. Hillier and Edward G. Allison, former employees of the two firms, are present members of the New York sales staff. In 1932 the 85-year-old crude drug firm of McIlvaine Bros., Philadelphia, was purchased, and the following year the Company moved headquarters to larger offices at 132 Nassau St., N. Y. City. In 1934 the drug-extract manufacturing plant was enlarged by purchase of property in Jersey City. The Company established a branch plant and offices at Chicago, with Harold Meyer, who already had nine years' experience in the New York office, as manager. The 32-year-old Drug Department of McLaughlin, Gormley & King Co. of Minneapolis was absorbed during the same year. In 1937 the 30-year-old Skagit Valley Golden Seal Farm at Burlington, Wash., and the 72-year-old drug firm of Murray & Nickell Manufacturing Co. of Chicago were purchased. The acquisition of the Golden Seal Farm is significant in that it enabled the Company to raise *Hydrastis canadensis* or golden seal root. The following year the Company bought the 15-acre manufacturing plant with extensive research and control laboratories at Lyndhurst, N. J., and extensive warehousing property at Brunswick St., Jersey City. With the purchase of the 68-year-old concern of Lloyd Bros., Pharmacists, Inc., manufacturing pharmacists of Cincinnati, Penick emerged as an aggressive factor in the drug trade.

In 1941 the Company acquired the Montville, N. J., plant, now known as the Montville Chemical Works Division, for the manufacture of fine chemicals. It moved to its present headquarters at 50 Church St., N. Y. City. Three years later the Company bought the Morganville, N. J., plant, as an adjunct to Montville Works and Jersey City plant at Tenth St., for further research and pilot-plant activities, and for expansion of the Export Department. It also purchased the 30-year-old firm of Compagnie Duval, N. Y. City, for further expansion of Essential Oils & Aromatic Chemicals Division.

In insecticides S. B. Penick & Co. has become the leading producer of the pyrethrum ingredient in the aerosol bomb so widely used in the control of malaria and other tropical insect-borne diseases during World War II. In cooperation with

the Fish and Wild-Life Service of the Department of the Interior, the Company evolved fortified red squill, used in the control of disease-carrying rats. In the early thirties Penick saw the tremendous possibilities of rotenone found in derris root. Just before the war, American consumption of this insecticide was 4,000,000 lb. a year. With the advent of the Japs in Malaya and the attendant cutting off of supplies of this insecticide, Penick botanists and chemists investigated the possibility of obtaining rotenone from cubé and timbo roots—fish poisons used by the South American Indians. Production was well under way when the Government took over this insecticide as critical material.

The 225-acre Pilot Farm, at Oley, Pa., believed to be the first project of its kind in the United States, is a vital step towards making America less dependent upon foreign imports. Besides furnishing drugs of superior quality, the farm also provides a dependable source of supply for alkaloidal drugs. Although some alkaloids have been produced synthetically, the professional dispenser relies largely on those produced from natural sources. Prior to World War II, only the narcotic alkaloids, plus strychnine and quinine were produced in the United States; others were imported from Germany and Switzerland, with France supplying a few. In 1937 S. B. Penick & Co. succeeded in producing emetine of superior quality; later, when atropine and homatropine were cut off, the Company began their production. These alkaloids, plus hyoscine, hyoscyamine, pilocarpine, eserine, strophanthin, ouabain, and arecoline were produced in quantities sufficient for both military and civilian needs. The Pilot Farm affords facilities for long-range study, painstaking care in research and experiment. Its surveys include agronomy, an effort to domesticate wild plant species, plant selection and breeding, greenhouse forcing, and the control of fungi and disease. One of its purposes is to determine whether active principles can be increased, especially in drugs possessing alkaloidal and glycosidal properties.

When the enemy overran Java and Sumatra, the Company brought totaquine to the attention of the Surgeon General and became one of the three firms to process cinchona bark into totaquine—a combination of the total crystallizable alkaloids of cinchona bark. When supplies of belladonna were cut off by the Nazi invasion of Central Europe, Penick bought acreage in six states and made intensive efforts to cultivate the few pounds of belladonna seed imported from Switzerland.

Another Penick division handles gums and resins, the chief items being arabic, tragacanth, and karaya gums. In the perfume line, Penick can supply more than 2,000 formulas and its ingredients. It also manufactures natural and synthetic estrogens gynestrol and diethylstilbestrol, rutin, ergot, and is the world's largest dealer in digitalis. It can also supply deertongue to flavor tobacco, mandrake root used as a cathartic, passion flower, a narcotic and sedative, and horehound herb for cough drops.

PENNSYLVANIA COAL PRODUCTS COMPANY (now the Penacol plant, Chemical Division, Koppers Company, Inc.,) succeeded the Bear Creek Manufacturing Co. which was chartered in Pennsylvania, 1916, for the purpose of building and operating a plant at Petrolia, Pa., to manufacture toluene by a new process. Completion of the plant was delayed until after the close of World War I and it remained idle until 1919, when a group of Pittsburgh investors, headed by Alvin A. Hoffmann, purchased it and other corporate assets and reorganized under the name, Pennsylvania Coal Products Co. Because of its proximity to raw materials and fuel, as well as to chemical markets, the location was ideal for the manufacture of resorcinol and other specialty chemicals not then made in the United States.

In its early years, the Company encountered numerous difficulties, and not until 1922 was commercial production of resorcinol begun. Despite a fire which destroyed the laboratory and offices in 1924, the Company continued its expansion by adding to the list of chemicals. Resorcinol, U.S.P., was made under the Dissosway process, and at a later date, *m*-nitro-*p*-toluidine, this being continued until 1940. The demand for resorcinol continued to increase, resulting in a program of remodeling and enlarging, completed in 1929. During that same year additional chemicals were made, including caproic acid and a number of specialty ketones.

In 1933 the manufacture of pyrocatechol was undertaken to supply the petroleum industry's need for an inhibitor, and the facilities erected at that time included a plant for making *o*-chlorophenol. In 1934 an inhibitor known as PCP No. 5 was introduced, and a year later a second inhibitor, PCP No. 6. Additional chemicals added before 1940 included phenolsulfonic acid, propiophenone, sodium sulfite, β-methylumbelliferone, 4,4'-dihydroxydiphenonesulfone, naphthalene sodium trisulfonate, and β-resorcylic acid. Prior to World War II, development work was carried on with a view to making lachrymatory gases, and as a result, Pennsylvania Coal Products was a major source of supply for military requirements of diphenylaminechloroarsine and chloroacetophenone, as well as magnesium arsenide.

In 1940 the Company undertook a research program under direction of Arthur J. Norton, plastics consultant, looking toward the wider use of resorcinol in that industry. His efforts resulted in room-temperature-setting adhesives which were used in large quantities in the military program for wood-bonding purposes, and have since become nationally known under the trade name, Penacolite. Many companies in the plastics industry followed this lead in the use of resorcinol, which has now become firmly established as a major raw material for that industry.

From the Company's inception, Alvin A. Hoffmann served as president and general manager until his death, when he was succeeded by Charles F. Hosford, Jr., previously treasurer and a director. In Dec. 1946, Pennsylvania Coal Products was acquired by Koppers Co., Inc., of Pittsburgh, which, for a time, operated the Petrolia company as a wholly owned subsidiary. Since Aug. 1947, the plant has been operated as a department of Koppers' Chemical Division, under the general direction of Dan M. Rugg, vice-president and general manager of that division. Hosford is now West Coast manager in Koppers' Chemical Division. Purchase of Pennsylvania Coal Products marks another step in Koppers' entry into the chemical industry and presages a further expansion into broader fields.

PENNSYLVANIA INDUSTRIAL CHEMICAL CORPORATION was chartered on Aug. 11, 1920, as the Pittsburgh Soda Products Co., but changed its name in 1924 under the same charter. Samuel G. Burroughs, a graduate chemist of Washington & Jefferson and Harvard, interested some Pittsburgh friends in starting a chemical company to manufacture dye intermediates. An old brewery building in Clairton, Pa., was leased and equipped to manufacture reducing agents for vat colors. Because of insufficient working capital, the Company soon decided to use the refrigeration machinery in the plant to manufacture ice, for which there was a good local demand, as a "pot boiler," while developing the chemical business.

In 1922 Burroughs engaged chemical engineer Robert W. Ostermayer, previously with du Pont and at the time in business for himself, to make a survey of the chemical possibilities at the Clairton plant. Ostermayer recommended that the ice plant be modernized and used as a revenue producer, that the plans for dye intermediates be abandoned, and that the Company utilize coke by-products as a basis for its chemical business. These recommendations were adopted: Ostermayer

was employed as plant manager, additional capital was raised, the plant was purchased, and then the ice plant modernized and operated profitably, while laboratory work was continued on chemical products.

Progress was slow. It was 1931 before the Company was ready to produce refined coal-tar solvents. Ralph H. Bailey, graduate chemist of Wabash and Harvard, was employed as research chemist, and Francis W. Corkery, a graduate of New Brunswick University, Canada, became director of technical sales. Considerable research and development work was carried on during the next five years, and basic patents were obtained on the utilization of various coke plant residues and the manufacture of coumarone-indene resins.

By 1937 it was feasible to discontinue the manufacture of ice and devote all facilities to the chemical side of the business. In 1938 a fire wiped out the seven-story chemical plant, but construction was immediately started on a new modern plant, and during 1939 this was placed in operation with improvements both in coal-tar solvents and resins. The trade name of Piccoumaron was adopted for the resins and Picco Solvents, for the solvents.

An entirely new line of resins, light-colored, soluble, straight hydrocarbon, was added in 1940, based upon polymers of β-pinene from turpentine. Patents were granted and the resins marketed under the trade name Piccolyte. During the war, production centered around the resins and solvents most needed for war work, and an outstanding achievement was the increased production of oils suitable for reclaiming natural rubber, synthetic rubber, and mixtures of the two.

The Corporation realized in the early 1940's that sufficient crude materials would not be available from coke and gas plants to take care of the constantly increasing demands for coumarone-indene resins. It became interested in the cracked petroleum oils as raw materials, and succeeded in making hydrocarbon resins from them. The carefully controlled cracking process developed by Ugite Sales Corp., a wholly owned subsidiary of United Gas Improvement Co. of Philadelphia, was of particular interest to the Corporation, which produced a line of fine synthetic resins from the Ugite materials. In 1945, when United Gas was prevented from further development in the chemical business and decided to dispose of Ugite, the Corporation purchased the Ugite plant at Chester, Pa., the United Gas patents, and its research laboratory in Philadelphia, taking over the entire technical and plant organizations. A complete resin plant was added to the Ugite plant at Chester during 1946. In addition to the large increase in the lighter-colored indene resins, the Ugite processes made possible new dark-colored resins called Resinex and Transphalt, which have been found very useful in the floor tile and rubber industries.

The latest addition to Picco products was a complete line of modified styrene resins called Piccolastic Resins, which are made in all melting points from liquids up to 150° C. Picco products go into adhesives, paper coatings and sizes, impregnants, chewing gum, rubber compounds, plasticizers and extenders, laminating agents, printing inks, plastic molding compounds, phonograph records, textile coatings, waterproofing and flameproofing coatings, polishes, paints and varnishes, floor tile, leather products, plastic cements, wire and cable insulation, etc.

Picco has its own technical sales and service department with full laboratory facilities to service the various industries. Sales are made through national sales organizations which maintain district and local sales offices in the principal cities. In addition to its own research laboratory in Philadelphia and its plant laboratories at Clairton and Chester, Picco has started a fellowship program at Battelle Institute for specialty items.

PENNSYLVANIA SALT MANUFACTURING COMPANY was incorporated Sept. 12, 1850, to meet what was then a pressing need in American home economy—the manufacture of lye for home soapmaking, a product it still makes. The father of the Company was George T. Lewis, granduncle of the president, Leonard T. Beale, and then a commission merchant for the products of his family's lead factory. Early in 1850 Dr. Richard Tilghman approached him with a new process for making caustic soda from salt, which was simultaneously offered to Charles Lennig, largest heavy chemical maker then in Philadelphia. Several interested persons agreed to acquire the patent, form a corporation capitalized at $100,000, and manufacture the alkaline salts of soda. This was the idea and birth of the Pennsylvania Salt Manufacturing Co.

Opinions differ as to why the name "Pennsylvania Salt Manufacturing Company" was chosen. Some historians say Pennsylvania state charters of that time were unduly restrictive of chemical companies, while there was a simpler section of the charter laws covering general manufacturing. Others believe the name was chosen to capitalize on the widely-known salt products. At any rate, the original business of the Company was then and is now the manufacture of chemicals. While salt has always been produced and sold, it has never been a major product.

The first meeting of the Company's stockholders was held Oct. 7, 1850, probably at the office of Samuel F. Fisher in Philadelphia. The original board of directors, all Philadelphians, included Charles Lennig, first president of the Company; G. T. Lewis, George C. Carson, Samuel Sims, and Fisher, with George Thompson serving as secretary-treasurer. At this meeting announcement was made of the purchase of a 70-acre site for the Company's first plant at East Tarentum, Pa., later named Natrona. The site was chosen because it was on the old Pennsylvania Canal, then one of the nation's main arteries to the West, and because the land covered both salt and coal deposits.

It early became apparent that Lewis had estimated correctly the market for lye, but under the Tilghman process manufacturing soon proved impractical without modification. Until these modifications were introduced there were no profits. The Company was kept alive by loans and further investments of its first directors. The first profitable year was in 1856 when net annual earnings were $1,047.58. The Company was then producing bleaching powder, Glauber's salt, bromides, Epsom salt, soda ash, and a few pyrites products, in addition to mining its own coal and making its own bricks. And in this year, George Thompson was granted a patent for "Saponifier," a household lye still made. It was sold in the forerunner of the modern tin can, made by a laborious process.

In 1860 the Company struck oil on its properties and was one of the first companies in America to enter the petroleum-refining business, with "Natrona Oil—equal to the best kerosene now known." It shipped 500 bbl. to London next year—the first shipment of a refined petroleum product from the United States. Its products then also included caustic soda, Saponifier Lye, sal soda, copperas, chloride of calcium, strong muriatic acid, nitric acid, and chloroform, and in the following year aqua fortis and benzine were added. In 1863, following a successful promotion of Saponifier, profits reached $146,132.22 and the first dividend, 5%, was paid.

By this time the salt wells at Natrona were supplying insufficient material for the Company's alkali products. New sources of raw material were sought, which brought about one of the unique agreements in American industry. In 1864 Henry Pemberton, Company superintendent, visited the Kryolith Co. in Copenhagen, Denmark, and in 1865 contracted to import 6,000 tons of cryolite a year from Ivigtut,

Greenland, to be used for the production of alkali products by methods originated by Julius Thomsen, superintendent of Kryolith. This first agreement has been renewed to the present day. By 1867 the Company was making sal soda, bicarbonate of soda, and caustic from cryolite, but the Thomsen process also gave alumina and a waste product, calcium fluoride or fluorspar. In addition, the importance of refined cryolite in porcelain manufacture was discovered and large sales were made. By 1868 the Company was also selling large quantities of "porous alum" made from cryolite, which later became one of its best-known and most profitable products, stimulating interest in the paper industry.

As the market for alum grew, increased facilities for sulfuric acid and other expansions were needed. In 1871, 66 acres were purchased in Philadelphia for a new plant, and in 1873 the general offices were moved there from Pittsburgh. The great demand for alum caused Pennsalt to import bauxite from France and to purchase a large halloysite deposit in Indiana in 1877. By this time the Company had given up its petroleum refining and concentrated solely on chemical manufacturing. In 1878 it reported to stockholders that "The credit standing of the Company today is second to no other chemical manufacturer in the country. No debts, no notes, everything purchased for cash." Until 1947, when its first preferred stock was issued, the Company's financing consisted only of its common stock. It has never passed a dividend in 83 years.

By 1883 Pennsalt was using large quantities of sulfuric acid as well as marketing it. The supply of domestic brimstone being insufficient, it began importing pyrites from the Rio Tinto interests in Spain. The roasting of pyrites for chamber acid left a valuable cinder residue which contained copper, iron, gold, and silver. The Company recovered these metals and copperas for many years.

The closing decade of the century was one of general prosperity for the Company. In 1890 the capital stock was increased to $2,500,000. The Company " was not seriously affected by the panic" of 1893 when sales totaled $3,723,077, a new high, and profits were $503,126. In this decade of mergers the Company was approached several times by the huge trusts and combines then forming, but refused all offers. During this period another event had a profound effect on Pennsalt. In 1888 Charles Hall, then enrolled at Oberlin College, discovered that molten cryolite was the perfect electrolyte for extracting aluminum from alumina. Although no Company records show this, it is said that he offered this invention to Pennsalt, but was turned down. At any rate, the Pittsburgh Reduction Co., later the Aluminum Co. of America, soon became a major customer for cryolite and to supply it with alumina, Pennsalt also established the original Bayer process at Natrona.

When it became apparent that cryolite was no longer practical as a raw material for the Company's products, the management reverted to salt. In 1898 it purchased 100 acres at Wyandotte, Mich., today its largest operation, over the vast salt beds underlying the Detroit River. This step was due largely to the foresight and efforts of John Hurford, head of the Pittsburgh sales office, who foresaw the ammonia-soda process displacing the cryolite-soda process. In 1901 the capital stock was increased to $5,000,000, partly to acquire patents for the electrolytic manufacture of alkali and kindred products and to develop the Wyandotte property. George Bell, inventor of an electric mercury cell, was brought over from England. Although this cell is quite effective for some electrolytic purposes, the early experiments were not so successful. Pennsalt spent over $25,000 on Bell's process, but it wasted too much mercury. In 1917, when old sewers were excavated in Wyandotte, they yielded a large quantity of mercury. It was seriously considered giving up the electrolytic process when Arthur E. Gibbs, a young English chemist

and engineer, joined Pennsalt at Wyandotte in 1903, bringing with him the first ideas for a diaphragm electrolytic cell. By 1908 the Gibbs cell was giving the Wyandotte plant a profit and has since proved to be the Company's most lucrative venture.

The move to Wyandotte once more made salt the Company's principal raw material, and almost the entire alkali production was moved there from Natrona, along with most of the Lye Department. About this time (1902) Pennsalt imported from Parsons Co., Newcastle-on-Tyne, England, the first steam turbine used in this country and now in Henry Ford's Dearborn Museum. Wyandotte's first product, salt, sold chiefly to Chicago meat packers. Soon the main interest shifted to salt products, especially chlorine, the new by-product of the electrolytic process. The first three years of the 20th century saw the beginnings of the electrolytic production of alkalies, bleaching powder, and chlorine compounds. Two sets of wooden-framed lead bleaching powder chambers, 10 chambers to the set, were early erected at Wyandotte. The bleaching powder went chiefly to the growing paper industry, which then imported most of its bleaching powder and had to be persuaded to try the domestic product.

While alkali manufacture was being consolidated and research in chlorine was being pressed at Wyandotte, the Company in 1904 remodeled its copper extraction works at Natrona, installed a new extraction plant in Philadelphia, doubled the Bayer alumina plant at Natrona. In 1905 improved methods of working copper by a wet extraction process were introduced. About this time (1900) a significant event occurred which launched Pennsalt into insecticide manufacture. A plant employee at Natrona, troubled by potato bugs in his garden, tried sprinkling his plants with powdered cryolite and thus discovered its insecticidal power. In 1905, due to increased demand for sulfuric acid, the little changed chamber process was supplanted by the new catalytic process. In place of platinum the Company successfully adopted the Verein or Mannheim system, using iron oxide. In 1909 Utley Wedge, superintendent of the Philadelphia plant, invented the Wedge furnace for treatment of pyrites smalls. The furnace proved so successful that it was placed on the market and subsequently sold also in Europe, South America, China, and Japan.

Meanwhile, Dr. F. H. Hirschman, seeking chlorine gas for detinning tin scrap (a process developed by the Goldschmidt Detinning Co. of Germany), made a five-year agreement with Pennsalt to buy chlorine at 2½¢ a pound, to be delivered by pipe line to a chlorine liquefaction plant Goldschmidt was to erect and operate at Wyandotte. This operation began in 1909, and that September Pennsalt shipped the first tankcar of liquid chlorine recorded in this country to Goldschmidt at Chrome (now Carteret), N. J. About the same time other companies were beginning to manufacture chlorine gas, chiefly for water chlorination. By 1912, when the capital stock was increased to $7,500,000, Pennsalt's chlorine production was sufficient to enter this field.

The opening of World War I and world-wide disturbances and industrial depressions reduced production in all Pennsalt plants 60%. But in 1915 the first war boom began and works were taxed to capacity. In 1916 a new alum plant, costing $225,000, was ordered at Greenwich Point and Company sales reached $10,855,415. During this entire period Pennsalt was shipping the only tankcars of liquid chlorine in this country, all to Goldschmidt, which in 1915 became the Metal & Thermit Corp. In 1918 the Government, entering into its first large-scale chemical warfare operations, built chlorine cars and ton containers to transport liquid chlorine for war purposes. All chlorine-making facilities in the nation were expanded to meet this demand. With the war, pyrites imports from Spain stopped and Pennsalt turned to the expanding production of domestic sulfur from the Southwest. All the

metal extraction business connected with the pyrites importation began to disappear.

By the war's end consumption of chlorine for detinning had advanced to the point where it nearly satisfied Pennsalt's increased war production of the gas. Shortly thereafter the substitution of liquid chlorine for bleaching powder in the pulp and paper industry provided another large market. To meet this change, the Company purchased the Metal & Thermit Corp. in 1922, whose capacity was 12 tons of liquid chlorine a day. Shortly thereafter the large German reciprocating compressors were replaced by Nash blowers, permitting an increase in capacity to 100 tons a day. The Company's first customer for this new business was the Marathon Paper Mills at Rothschild, Wis. The Company then began operating its own fleet of liquid chlorine tankcars, purchasing 15.

In 1921 sales dropped to their lowest in years, $6,083,055. The Company incorporated that year the Natrona Light & Power Co. and controlled and operated the Mechanical Furnace Co., the Wyandotte Southern Railroad Co., and the Natrona Water Co. Importation of pyrites from Spain was briefly resumed, but by 1924 this business was concluded by Pennsalt. Despite a business recession, the Company continued to expand, principally in chlorine development, and in 1924, incorporated the Pennsalt Coal Co. at Natrona. In 1925 the Research Department, then located in the Philadelphia office, was entirely reorganized, and Pennsalt purchased the Michigan Electrochemical Co. at Menominee, Mich., to establish more firmly its large chlorine and bleaching powder business among paper mills of Wisconsin and northern Michigan. This subsidiary made only liquid chlorine. In 1926 a new building was erected in Philadelphia as a chlorine-filling station and for the manufacture of sodium hypochlorite, and the Eagle Lye Works at Milwaukee was purchased. Pennsalt's manufacturing was consolidated at Wyandotte and sales in Chicago.

In 1927 Yellott F. Hardcastle, then superintendent at Wyandotte and now vice-president, and North E. Bartlett, then manager of sales and later vice-president, visited the Pacific Northwest to study the expanding pulp industry. They purchased a factory site at Tacoma, that was the beginning of the Tacoma Electro-Chemical Co., now the Pennsylvania Salt Manufacturing Co. of Washington, a wholly owned subsidiary. In June 1928, the directors authorized construction of an electrolytic plant at Tacoma, which went into operation a year later. Also in 1928, still another product of the original process of salt electrolysis was put to use. An agreement was made with Werner G. Smith Co., later a subsidiary of Archer-Daniels-Midland Co., under which Pennsalt sold it hydrogen, until then generated as a waste product, for hydrogenation of oils. Wyandotte Oil & Fat Co., recently changed back to Werner G. Smith Co., was organized and land and a building on Pennsalt property at Wyandotte were leased to it.

L. T. Beale, on the board since Sept. 1923, was elected president of the Company, Oct. 25, 1928, succeeding Miers Busch. In the highly successful year of 1929, the Development & Research Department was again reorganized and $100,000 appropriated to it. General Laboratories, Inc., of Madison, Wis., was acquired with its B-K line of dairy and household bactericides. New products added to Pennsalt's list were ammonium persulfate and ferric chloride.

Despite decreased earnings, $497,000 was spent in modernizing and improving equipment in 1930. Next year net earnings dropped more than 50%, the dividend rate was cut from 10% to 8%. Yet the Company made three important steps. With I.G. Farbenindustrie of Germany it formed Pen-Chlor, Inc., an American company to manufacture and sell Perchloron, a high-test bleaching concentrate; it held 50% of the stock. With J. T. Baker Chemical Co. of Phillipsburg, N. J., it

formed Taylor Chemical Corp. to make carbon bisulfide and carbon tetrachloride, the latter in a unit built at Wyandotte. To make further use of the hydrogen produced at Wyandotte, a unit was built there to make ammonia. The Company also added hydrofluosilicic acid to its line.

In 1932, despite further reduction in Company earnings, the Tacoma subsidiary showed its first profit. Operations at the Michigan Electrochemical Co. were suspended because of the greatly reduced selling price of liquid chlorine and high costs of production, and Wyandotte took over production, tankcars, and other equipment. In 1933 the General Laboratories plant at Madison was closed and its production moved to Wyandotte. The Brackenridge Light & Power Co. was absorbed by the Natrona Light & Power Co. Net earnings in 1933 fell to $325,745, yet the Company paid a 6% dividend. By 1934 the improved Tacoma plant, modernized power facilities at Wyandotte, and expansion of Perchloron manufacturing facilities were in full swing, and in 1935 sales were 37% above the low of 1933—30% being in specialties. To bring together the hydrogen generated at Tacoma and the abundant natural oils found in the territory, the Archer-Daniels-Midland subsidiary and Pennsalt formed Wypenn Oil Co., Inc., each owning 50% of the stock. In 1936 a process for production of anhydrous sodium orthosilicate for metal cleaning was perfected, starting one of the Company's most important present-day lines.

It is interesting to note that the Civil War is not mentioned in the Company's records, the Spanish American War was noted only as it affected imports of pyrites (imported just the same by British ships), and in the First World War, although full production facilities were made available to the Government, few details are given. As Pennsalt entered 1940, however, and began rapid reconversion to war economy, changes occurred. The Greenwich Point plant in Philadelphia, which had been making sulfuric acid. sulfate of alumina, and many other products for more than 70 years, was sold, to be vacated after the war. A new site was purchased at Cornwells Heights near Philadelphia. A pioneer in fluorine chemistry, Pennsalt in 1940 purchased Sterling Products Co. at Easton, Pa., thus acquiring production of hydrofluoric and anhydrous hydrofluoric acids, and a line of fluorine laundry and dry-cleaning products. In this year also it bought I.G. Farbenindustrie's share in Pen-Chlor, Inc., absorbing this unit into Pennsalt. Just before the switch to wartime production, the Company was selling its products to the 20 largest industries, none of which consumed more than 12% of its output. They were, in order of size, iron and steel, pulp and paper, chemical, laundry and dry cleaning, textile, aluminum, farm and poultry, ceramic and glass, sewage and water treatment, solvents, porcelain enameling, fertilizers, household goods, soap, insecticide, dairy, oil refining, ice and refrigeration, rubber, and paint.

The major impact of World War II was felt in Pennsalt's cryolite position. On hand was a normal supply for two years, but vastly greater quantities were needed for aluminum production. Denmark had been overrun and there was imminent danger that Greenland would be cut off. Henrick Kauffmann, Danish Minister in Washington, was left to administer Greenland. He named a five-man advisory committee, including Beale, to help him. From this country supplies and arms were sent to Greenland and imports of cryolite were convoyed by American warships even before Pearl Harbor. By 1941 nearly all Pennsalt's capacity was geared to war and extensive confidential research work was being conducted for the Government. Property was acquired at Portland, Ore., on the Willamette River, for a new plant to make sodium and potassium chlorates. Sales increased 19%, but earnings decreased 13.8%, more than $3,500,000 having been spent on plant expansion and improvements. George B. Beitzel, manager of sales, and

Frederick C. Shanaman, president of the Pennsylvania Salt Manufacturing Co. of Washington, were elected vice-presidents that year.

By 1943 Pennsalt was the largest producer of anhydrous hydrofluoric acid, essential in the production of high-test gasoline, in the country. In that year it organized the Tulsa Chemical Co. at Tulsa to produce this product, holding a 50% interest. In 1944 the Taylor Chemical Corp., operating plants at Penn Yan, N. Y., and Wyandotte, purchased Pennsalt's controlling interest and sold to it the Wyandotte carbon tetrachloride facilities and inventories. Dr. S. C. Ogburn, Jr., had joined Pennsalt as manager of research and development the previous year, and in 1944 the Company, needing room for greatly expanded research, purchased Whitemarsh Hall, the former Stotesbury estate near Philadelphia. The research staff was increased and Dr. W. A. La Lande, Jr., joined the Company as director of research. War work was given highest priority, but the Research Department and Company management were also pursuing research for postwar development.

The return of peace in 1945 found Pennsalt in a strong position and few reconversion problems. Its stock was split five for one and listed for the first time on the N. Y. Stock Exchange. With a long background of experience in insecticides and having done research with DDT and other insecticides for the Army, Pennsalt purchased the assets for production of technical DDT from Elko Chemical Works, Inc., of Pittstown, N. J., and later bought Cotton Poisons, Inc., of Bryan, Tex., to serve the large need for insecticides in the South and to add calcium arsenate to its line. Postwar, Pennsalt was one of the first to offer DDT to the public, and now operates a DDT plant at Natrona and has recently built the first technical DDT producing unit in the West at Portland, Ore. For many months it provided large quantities of certain chemicals to the Manhattan District Project, producers of the atomic bomb, for which it was congratulated by the War Department.

In June 1946, the Company announced the first general offering in America of fluorine for experimental purposes, the result of long, independent research. With the return of full-scale peace production, it listed 52 chemicals and more than 150 brand products, including insecticides, weed killers and fumigants for the Agricultural Chemicals Division; cleaners, bactericides, insecticides, and weed killers for the B-K Division; alkaline detergents, bleaches, dry-cleaning compounds, laundry blues, laundry sours, and stain removers for the Laundry & Dry Cleaning Division; and for the Special Chemicals Division alkaline cleaners, solvent-type cleaners, resin-type corrosionproof cements, silicate-type corrosionproof cements, corrosionproof paint, stripping compounds, inhibitors, electroplating compounds, pickling and descaling products, and specification cleaners. For the Household Products Division the Company is making Knox-Out DDT and lyes, including Lewis' Saponifier Lye.

Chemicals now listed for sale by the Company include aluminum hydroxide, oxide, and sulfate; ammonia and anhydrous ammonia; ammoniacal liquor; ammonium chloride and persulfate; calcium hypochlorite; carbon tetrachloride; liquid chlorine; liquid and anhydrous ferric chloride; ferrous carbonate; fluorine; hydrochloric, hydrofluoric, anhydrous and aqueous hydrofluoric, nitric, sulfuric, and hydrofluosilicic acids; hydrogen peroxide; potassium persulfate; sodium aluminate, carbonate (soda ash), chloride, fluoaluminate (cryolite), hydroxide, hypochlorite, and sulfate.

The Company has sales offices in Bryan, Tex., Chicago, Cincinnati, Detroit, Los Angeles, Paterson, N.J., Pittsburgh, Portland, Ore., St. Louis, Tacoma, and Washington, D. C., and operates plants at Cornwells Heights, Easton, and Natrona; Bryan, Portland, Tacoma, and Wyandotte. Its wholly owned subsidiaries are Natrona Light & Power Co., Natrona Water Co., Pennsalt Coal Co., Pennsyl-

vania Salt Manufacturing Co. of Washington, and Wyandotte Southern Railroad Co. It owns 50% of the stock of the Wypenn Oil Co., Inc.

Present officers are Leonard T. Beale, president; Y. F. Hardcastle, George B. Beitzel, and Frederick C. Shanaman, vice-presidents; Warner R. Over, secretary-treasurer; Thomas W. Cox, assistant secretary-assistant treasurer; Stanley L. MacMillan and Eugene J. Harrington, Jr., assistant treasurers; Edward F. Beale, controller; William P. Drake and William F. Mitchell, assistant vice-presidents; and Richard L. Davies, assistant to the president. The directors are Leonard T. Beale, Leonard H. Kinnard, Otho E. Lane, Francis Boyer, Charles G. Berwind, Alexander J. Cassatt, Richard T. Nalle, Charles B. Grace, and Y. F. Hardcastle, all of Philadelphia.

CHARLES PFIZER & COMPANY, INC., began in 1849, when Charles Pfizer and Charles F. Erhart formed a partnership to produce fine chemicals in Brooklyn, New York. American industry at that time stood at the threshold of its most explosive growth. Gold had been discovered in California. The clipper ship era of our foreign commerce had been opened by the launching of the *Rainbow* in 1845. Fewer than 1,500 miles of rails were laid, but this was to increase more than tenfold in the next three years. The market for chemicals was insignificant compared with present consumption, and of the three largest industries—flour, iron, leather—only tanning was an important consumer of chemicals. Chemical plants were then individually owned operations with limited equipment and very small output, coupled with crude processes. Dyes and drugs were chiefly of vegetable origin. Our alkalies were imported. Philadelphia, with three makers, was headquarters for fine chemicals.

Sensing the opportunity to capitalize their chemical training, Pfizer and Erhart agreed to produce chemicals of the highest quality and to specialize in certain chemicals not commonly made in this country. Today, nearly a century later, the Company is the oldest American chemical manufacturing enterprise continuously operated under the same name. Its officials, for the most part, have been with the organization for over 25 years: George A. Anderson, chairman of the board; John L. Smith, president, John E. McKeen, Fred J. Stock, Albert A. Teeter, and Elmer C. Otto, vice-presidents; Louis M. Timblin, treasurer; and John L. Davenport, secretary.

Since 1849, the Company has expanded around its original site, has acquired a substantial interest in a British chemical concern, and has established offices in New York, Chicago, and San Francisco. But more noteworthy than its physical growth is the ever-growing list of the Company's contributions to the development of chemical manufacture. It has a record of consistent manufacturing and merchandising policies unique in the annals of the chemical industry.

When Pfizer and Erhart first manufactured chemicals, they had an advantage over most of our pioneer chemical makers of knowing the principles of chemistry and the practical application of chemical processes in commercial operation. Their technical skill was coupled with sound commercial judgment, and though the early growth of the business was slow, it was steady and continuous. They began operations in an ordinary corner lot in Brooklyn: today the main plant in Brooklyn covers approximately eight acres; with additional property on the East River at Grand St. where the Company maintains its terminal warehouse; and on Newton Creek six acres for further expansion. In 1946 the Company acquired from the War Assets Administration the "Victory Yard" property on the Thames River at Groton, Conn., used during World War I as a submarine-building base by the Electric Boat Co. Purchase of land adjacent to the "Victory Yard" brings the

total site to approximately 60 acres, including 33 buildings. The Company recently (1947) purchased the Citro Chemical Co. of Maywood, N. J.—established in 1903—manufacturers of caffeine, acetanilide, and Phenacetin. Also in 1947, Pfizer executed a lease agreement with the U. S. Government covering the Vigo plant, Terre Haute, Ind. This plant will be utilized for the production of antibiotics such as streptomycin and penicillin, as well as for the manufacture of certain fine chemicals.

The first Pfizer product was the vermifuge santonin. Between 1850-55 the Company began manufacturing potassium iodide, iodine resublimed, iodoform, calomel, corrosive sublimate, red and white precipitates, bismuth subnitrate, bismuth subcarbonate, and related preparations; in 1860, refined borax, boric acid, and refined camphor; in 1863, cream of tartar, tartaric acid, and Rochelle salt. The first American production of the tartars was in response to their growing demand in the food industry and in medicine. Wine-making France and Italy were the first to work up crude "argols" for these by-products, and prior to our Civil War they supplied our market.

Another agricultural by-product originating in southern Europe, which became an important Pfizer product—citric acid—was first added in 1880. The organic acid was then made from citrate of lime imported almost wholly from Italy, where it was prepared from cull citrus fruits. Realizing its importance and appreciating the implications that almost its entire production depended upon imported raw material, the Company several years before World War I investigated the possibility of producing citric acid by a natural vegetative mold fermentation. This work was climaxed in 1923 by the first commercial production of citric acid by fermentation, and led to the Company's present status as a leader in the field of the world's fermentation chemistry. Citric acid, which was selling in the latter years of World War I at $1.25 per pound, is now selling at 23¢ a pound—the outcome of a long-concentrated, particular research for the production of chemicals by fermentation.

Further investigation of fermentation methods for the production of fine chemicals resulted in such important new products as fumaric acid, gluconic acid, itaconic acid, and intermediate chemicals used in the manufacture of other products. With this background, and its extensive experienced staff of bacteriologists, biochemists, organic chemists, and chemical engineers skilled in the field of industrial fermentation, it was natural that Chas. Pfizer & Co. should become interested in the production of antibiotics which are produced by fermentation processes, the principal ones being penicillin and streptomycin. When the Allies of World War II were seeking an effective antibiotic to save the lives and limbs of their fighting men, an intensive program was inaugurated by the U. S. Government, which resulted in bringing penicillin to full-scale manufacture in a relatively short time. From the start Pfizer has been the world's largest producer of this drug.

Coincident with the development of the Company's fermentation processes, was an extension of its research activities into the entirely different field of organic synthesis. This has resulted in the successful development of highly efficient processes for the manufacture of vitamins and several new organic acids not previously available. The field of organic synthesis continues to represent an important phase of the Company's program of research and development.

These are but a few of the important factors which have made Pfizer so intimate a part of the progressing chemical industry of America. Established by chemically minded men, plant and control methods represented from the beginning the then-latest ideas of chemical manufacture. This high tradition has long been customary, and through the intervening years so prolific in discovery and progress,

Pfizer has kept pace with the growth of scientific knowledge and technical invention.

The founders continued as active heads of the Company until Charles F. Erhart died in 1892. Charles Pfizer retired in 1900, after half a century of active leadership. John Anderson joined the organization in 1873 and steadily progressed through responsible positions, in 1882 locating in Chicago to establish a Western sales office and warehouse. In 1892 he returned to New York as general manager. Two years later Franklin Black, who had entered the employ of the Company in 1875, was called to New York from Chicago to take care of sales. On Charles Pfizer's retirement, the Company, on May 21, 1900, was incorporated as Chas. Pfizer & Co., and John Anderson, Emile Pfizer, William H. Erhart, and Charles Pfizer, Jr., were elected directors. The officers elected at that same meeting were president, Charles Pfizer, Jr.; vice-president, Erhart; secretary, Anderson; treasurer, Emile Pfizer.

In 1907 Charles Pfizer, Jr., retired, and Anderson became chairman of the executive commitee and treasurer; Emile Pfizer, president; Erhart, vice-president; and Black, secretary. Emile Pfizer, son of Charles Pfizer, Sr., entered the employ of the Company in 1887. He celebrated his 50th business anniversary in 1937 and died in July 1941. Erhart, until his death in July 1940, found his greatest interest in scientific and production developments in the Brooklyn plant. This official personnel continued until 1914, when George A. Anderson, son of John Anderson, who had joined the staff in 1910, became treasurer. Black, who was secretary until 1925, when he became treasurer, died in 1934. He had celebrated his 50th anniversary with the Company in 1925. William H. Erhart and John Anderson both passed away in 1940, Anderson having celebrated his 50 years with the Company in 1923.

In the early years the New York office was for a short time located on William St. It was then moved to Beekman St., which was at that time in the heart of the wholesale drug section of the city. In 1868 the office was moved to the present premises at 81 Maiden Lane, which still houses the executive and sales headquarters.

PHARMA CHEMICAL CORPORATION was organized in 1919 in New York to acquire the assets and operations of the Pharma Chemical Co., founded by Eugene A. Markush in 1917. Albert J. Farmer, one of the organizers, while dismantling one of his plants making products controlled by Nuyens & Co., became interested in the dyes and pharmaceuticals plant owned by Eugene A. Markush who came to Farmer in search of machinery.

The Pharma Chemical Co. was engaged in the production of pharmaceuticals and dye specialties that were scarce or unobtainable or originated with it. In 1918 it successfully produced important drugs for the influenza epidemic on a manufacturing scale. Appreciating the business potentialities of the Pharma Chemical Co. and impressed by the results attained in the two years of its existence, Farmer joined with Markush, Charles M. Richter, Frederick Diehl, Thomas Duntze, Albert L. Crone, C. W. Welty, Francois E. Nuyens, Augustus Lemkau, C. G. Rehm, Mortimer W. Byers, and Ernest Knecht in organizing the Pharma Chemical Corp. The board of directors consisted of Farmer, Markush, Byers, Duntze, Nuyens, Knecht, and Richter.

The Corporation was the first organization in the United States to produce and patent pyrazolones, basic materials for many important drugs (antipyrine, pyramidon, etc.) and dyes. One of the first pyrazolone dyes produced was tartrazine, also used in the manufacture of color lakes, and in purified form as a certified

food color. Fast light yellow was an early achievement of the Corporation. Then came the acridines and phosphines for cotton, silk, and leather dyeing, followed by phenyl-methyl-pyrazolone, wool colors, and a new line of direct colors for cotton, marketed under the trade name of Pyrazolines. Successively, a complete line of developed dyes for cotton and rayon was marketed under the name Dipyrazo Colors. Also, the wool color line was extended and silk colors under the name Pharmacines were introduced by 1929. A great number of these dyes obtained patent protection. In 1931 milling colors were introduced, also a full line of colors adaptable to silk and wool under the name Pharmatex Dyes.

Research work, which was initiated in 1920, and further developments in 1930-32 resulted in azoic dyes introduced as Pharmols and Pharmasols which were patented. Since then, many additional developed colors have been added, also a direct fast-to-light group, Pyrazolines; wool colors, Pharmanil; half-silk hosiery and wool colors, Pharmatrals; a line of chrome colors and color salts.

During World War II certain equipment in the Pharma plant was adapted to Halocrin, one of the components of Atabrine, and plant production was accomplished within one month after government authorization. Limited amounts of DDT were also manufactured for the Government during the period in which the subsequent large-scale producers were converting to volume production.

In Sept. 1930 Albert J. Farmer died and his place was taken by Charles M. Richter who, up to that time, had not been active in the business. The present officers and directors are: Richter, president and treasurer; Dr. Eugene A. Markush, vice-president; Arthur C. Hahn, secretary. Jeanne Richter is the fourth director. Plant and laboratories at Bayonne occupy several acres with some 18 buildings in full operation at the beginning of 1947. Business offices are in the Flatiron Bldg. at 175 Fifth Ave., N. Y. City.

PHILADELPHIA QUARTZ COMPANY had its beginning on July 21, 1831, when Joseph Elkinton opened his shop in a combination store and dwelling at 377 South Second St., Philadelphia. Elkinton, who had been a missionary among the Tunessassa, New York Indians, for the Society of Friends, started his soap and candle business with the sum of $1,697.33¾, and his products sold here and abroad. In 1855 the firm name became Joseph Elkinton & Son, when the founder took his son, Joseph S., into the business. The younger son, Thomas, who was also working with his father, found reference to soluble silicates in the foreign literature. This inspired experiments in the manufacture of silicate, which occurred in 1858 and was substituted for rosin in their own soaps to improve the washing action.

During the Civil War, when rosin supplies were scarce, the Elkintons began to sell silicate of soda to other soapmakers. The first recorded sale was in Jan. 1861. The manufacture of silicate was carried on in the Second St. plant along with soap and candles, although the demand for the latter was waning because of the introduction of the kerosene lamp. Another change in firm name occurred in 1862 when Joseph Elkinton withdrew, leaving the conduct of the business to his sons under the name of Joseph S. & Thomas Elkinton. Research continued both in improving manufacture and discovering other uses for silicate. Thomas Elkinton was granted a U. S. Patent in 1863 for "Improvement in Manufacture of Alkaline Silicate."

With increasing demand for silicate, a new plant was erected at 9th and Mifflin Sts., Philadelphia, and in 1864 a partnership, known as Philadelphia Quartz Co., was formed with John Greacen, Jr., and Samuel Booth. Soapmaking continued at the original plant. In 1868 the partnership was terminated and both the silicate

and the soap factories were operated without change by the Elkintons. Joseph S. was the manufacturer and trader, and Thomas the investigator and pioneer. The adhesive properties of silicate of soda had already been explored by the Elkintons when the corrugated paper box was introduced as a shipping container in 1900. In time the use of silicate for laminating the corrugated paperboard became as important as the use in soap.

The expanded needs of their customers in the Midwest made necessary the building of a plant at Anderson, Ind., in 1889. The soap business was terminated in 1904 when the Elkintons incorporated the Philadelphia Quartz Co. for the manufacture of silicate of soda exclusively. The board of directors were: William T. and Alfred C. Elkinton, sons of Joseph S. Elkinton, George W. Goudy, Ephraim Smith, and William H. Stanton. Smith became president and William T. Elkinton, vice-president and treasurer. William T. Elkinton was later elected president, serving until his death in 1933. In 1905, with the opening of the Chester, Pa., plant, the Philadelphia plant was closed.

On the eve of its centennial in 1930, the Company introduced two new industrial alkalies, sodium metasilicate and sodium sesquisilicate in free-flowing form, which were patented by Chester L. Baker, now chemical director.

Soluble silicates have had wide usefulness in chemical processes largely due to the researches of James G. Vail, whose American Chemical Society Monograph *Soluble Silicates in Industry* was published in 1928. Engaged by the Company in 1905 as a chemist, he was chemical director, 1931-40, and today is a director and vice-president. From the original use in soapmaking, the Company's research has extended the uses of silicates to more than 15 industries, including paper, paperboard, oil, rubber, textile, laundry, mining, ceramics, glass, enameling, foods, metal, cooperage, construction, zeolites. Other uses have been developed, such as the coating of granules used on asphalt shingles, the commercial washing of apples, the solidification of porous earth, the prevention of corrosion in hot and cold water lines, coagulating aids for raw water supplies and waste waters.

In addition to Anderson and Chester, the Philadelphia Quartz Co. operates plants at Baltimore, Gardenville, N. Y., Jeffersonville, Ind., Kansas City, Kans., Rahway, N. J., St. Louis, and Utica, Ill. Its general offices are in Philadelphia. Three other plants located at Berkeley and Los Angeles, Calif., and Tacoma, Wash., are operated by the Philadelphia Quartz Co. of California, a subsidiary owned jointly by the Philadelphia Quartz Co. and the Stauffer Chemical Co. Its directors are: Alfred W. (president), J. P. and Thomas W. Elkinton, representing Philadelphia Quartz, and Theodore A. Haschke, Hans Stauffer, and Ferd W. Wieder, representing Stauffer.

The Canadian subsidiary is National Silicates, Ltd., with general offices and plant at Toronto, owned by Philadelphia Quartz and G. F. Sterne & Sons, Ltd., Brantford, Ontario. Its directors are J. P. and Thomas W. Elkinton (president), William Martin, and James A. Norton, representing Philadelphia Quartz, and Edward T. Sterne, representing Sterne.

The present directors of Philadelphia Quartz Co. are Chester L. Baker, manufacturing and chemicals; Alfred W. Elkinton; J. Passmore Elkinton; Thomas W. Elkinton, president; William Martin, purchasing and traffic; James A. Norton, finances; Edwin A. Russell, sales; James G. Vail.

PITTSBURGH COKE & CHEMICAL COMPANY is not one of our larger chemical companies, but its evolution from a manufacturer of pig iron to a producer of coal chemicals is of interest. Known by its present corporate name only since Oct. 1944, Pittsburgh Coke & Chemical evolved from Pittsburgh Coke &

Iron Co. (1936-44), and its predecessor, Davison Coke & Iron Co. (1928-36). The latter was founded "to manufacture pig iron, coke, and cement." At the time of the original purchase from United States Steel Corp., the Company property, consisted of a 550-ton-per-day blast furnace on 159 acres at the upstream end of Neville Island in the Ohio River, just below Pittsburgh. This blast furnace was enlarged and modernized by the addition of up-to-date blowing equipment. A 3,000-bbl.-per-day cement plant was built to utilize the blast-furnace slag. A complete by-product coke plant and a gas purification and pumping system completed the triangle of facilities for integrated production. Thus, much of the coke produced at the coke plant was available for the blast furnace and practically all of the slag from the blast furnace was utilized by the cement plant—while the pig iron was sold to the foundries in the Pittsburgh district. By Oct. 1929, the predecessor company was in a sound manufacturing position based on economical water transportation and availability of bulk raw materials.

With the depression of the early thirties came realization that even the giant steel business was not immune to economic upheaval and that diversification was the soundest safeguard. Davison Coke & Iron with its coke plant as a basis, began to slant objectives toward the coal-tar chemicals. A tar-distillation unit was started Jan. 1, 1939, the distillates at first selling to other companies and the remaining tar marketed for road building and maintenance purposes.

Motivated by the sulfa drugs, about 1938 a pyridine plant was added. So great was the demand, it was necessary for the Company to purchase crudes from other coke-oven operators. The present company has become the second largest Amercan producer of refined pyridine. In Apr. 1940, a sulfuric acid plant with a capacity of 60 tons per day, was put into production. In Aug. 1942 another unit increased capacity to 110 tons of 60° acid per day. A tar acid plant was installed in Aug. 1941 to recover and refine crude tar acids to pure phenol, meta para cresol, and *o*-cresol. Then a semirefined naphthalene plant was put into operation in Apr. 1942, forerunner of extended facilities for production of pure naphthalene. During World War II, Pittsburgh Coke & Iron, under contract from Defense Plant Corp., began a phthalic anhydride plant, capacity over 4,000 tons annually. This plant was not completed and in operation until 1948, when it was purchased from Defense Plant Corp. and will utilize the pure naphthalene made by the Company to manufacture phthalic anhydride.

In 1942 recovery of hydrogen sulfide and cyanide gases from coke-oven gas was started for the manufacture of sulfuric acid and sodium cyanide, respectively. In the latter half of 1941, the Chemical Warfare Service needed new readily available domestic sources of activated carbon for gas masks. Practically all gas mask carbon had been made from Dutch East Indies coconut shells. Pittsburgh Coke & Iron developed a process of manufacturing activated carbon from bituminous coal and started operations in Feb. 1942. The process was so successful that a second plant was added at Carnegie, Pa., Jan. 1943, and the original plant simultaneously expanded.

In Oct. 1944, the name was changed to Pittsburgh Coke & Chemical Co. as more nearly descriptive of the Company's objectives in the chemical field. At the end of World War II, the two activated carbon plants were purchased from the Army, and in Apr. 1946, the Carnegie plant was completely dismantled and the Neville Island unit changed to production of commercial activated carbon. An urgent need was for a satisfactory activated carbon for use in the absorption of streptomycin. Pittsburgh Coke & Chemical was successful in developing a satisfactory product for this use and supplies a major portion for the production of this drug.

The Company has undertaken production of a number of the new agricultural chemicals from coal-tar derivatives, which were developed during World War II. Already in production is α-naphthylthiourea, which utilizes the sodium thiocyanate and α-naphthylamine produced from the Company's primary chemicals. Another new plant has just been completed (1947) for production of the fungicide, *p*-aminophenyl mercuric acetate, which also has wide industrial uses. New plants are in various stages of completion for dinitro-*o*-cresol, 2,4-dichlorophenoxyacetic acid, and isopropyl n-phenyl carbamate.

Chemical products of Pittsburgh Coke & Chemical now include: activated carbon, alkylmethylpyridinium chloride, α-naphthylthiourea, benzene, bituminous pipe coatings, coke-oven gas, creosote, cresols, dinitro-*o*-cresol, isopropyl n-phenyl carbamate, solvent naphtha, naphthalene, α-naphthylamine, oleum, *p*-aminophenylmercuric acetate, phenol, phthalic anhydride, picoline, pitch, pyridine, quinoline, sodium cyanide, sodium thiocyanate, sulfate of ammonia, sulfuric acid, tar-acid oils and bases, tar, toluene, xylene.

The Company has completed additional laboratory and pilot-plant facilities to assure even more rapid progress in the future, so it seems destined to achieve a position of growing importance in the chemical industry.

PROCTER AND GAMBLE COMPANY started out as a partnership in Cincinnati, in 1837, when there were few business enterprises west of the Alleghenies which could rightfully be called industries, much less chemical industries. Colonial days were not far behind and Cincinnati was still a frontier town. It was a fast-growing community located in a fertile area, protected by an army post, and dependent on river boats for communication with similar communities at Pittsburgh, Louisville, Memphis, and New Orleans. Self-sufficiency was still a characteristic of the townfolk; and one of the duties of the Cincinnati housewife was to make soap by boiling the fat remnants from her kitchen with lye extracted from wood ashes.

In 1837 the effect of recent discoveries by Chevreul, Scheele, Leblanc, and other European chemists concerning the nature of fats, glycerin, and alkali had not yet been felt by American soapmakers and certainly had not reached as far as Cincinnati. Their application was soon to revolutionize soapmaking and change it from a handicraft into a chemical industry, but when William Procter and James Gamble became partners their lack of chemical training and knowledge was far from an insurmountable handicap. They had imagination, industry, and adaptability to rapidly changing conditions, which they pooled, together with approximately $8,000.

Procter was born in England in 1801. He left school at 16 to be apprenticed to a general storekeeper, and incidentally learned the art of hand-dipping candles. He then set up his own woolen shop in London, but when a robbery and a fire wiped out his business he set out for America and Cincinnati. Upon arrival here, the plentiful supply of tallow from local stock raising encouraged him to enter the trade of candlemaking. James Gamble was born in Ireland in 1803 and emigrated to America with his family when he was 16. Although originally heading for Illinois, they decided to stay in Cincinnati. At 25 Gamble started his own soap business, after several years' apprenticeship.

Soon after Procter began making candles and selling them from a wheel barrow through the streets of Cincinnati, he also arranged to sell Gamble's soap. Their association was strengthened when the two men married sisters, and since the raw materials, manufacture, and distribution involved in soap and candlemaking were complementary, a partnership soon resulted.

During the early days of the business, tallow, grease, and wood ashes were collected from hotels, butchers, and the larger households in exchange for manufactured soap or candles. The collected fats were rendered by heating in open kettles, with rendered tallow being used in candlemaking and soft fats in soapmaking. Candlemaking was a slow process of dipping a wick into melted tallow, cooling, and repeating the procedure until the candle reached the desired thickness. Soap was made in a large cauldron by boiling rendered fats with potash lye obtained from pouring boiling water over wood ashes. The soft, potassium soap was then converted to sodium soap by "salting out" with common salt. Soap was delivered in bulk to storekeepers, who sold it by weight, cutting off a piece to suit the wish of the purchaser.

Competition was chiefly local. The large New York soapmakers, B. T. Babbitt & Co., D. S. Brown & Co., Enoch Morgan's Sons, and Colgate & Co. were limited to their local markets by inadequate transportation, and Procter & Gamble's competition was mainly from Cincinnati housewives who still made their own soap. Despite this, Procter & Gamble's business soon was increasing rapidly; a large site near the stockyards on what is now Central Ave. was chosen for a new factory. Cincinnati by 1840 was fast becoming an important packing center and an ample supply of fats for soap and candlemakers was assured.

Up to this time Procter & Gamble had, without basic knowledge of the soapmaking process, produced superior products through reliance on the empirical manufacturing rules which they had evolved. However, the results of the French chemist Chevreul's original research into the nature of fats were now being felt in the soap industry. A method for splitting fats into fatty acid and glycerin through lime saponification had been discovered in 1831 by deMilly, a contemporary of Chevreul's. When the lime saponification process was adopted by Procter and Gamble it was probably the first use by the partners of a chemically developed method. This process further strengthened the association of candle and soapmaking, since the only satisfactory use for the by-product oleic acid was found to be in the soap kettle.

Understanding of the chemistry of soapmaking became more and more important as a variety of new fat stocks was made available. Rosin was being used to make an inexpensive laundry soap with good detergent properties. Coconut oil had been introduced as early as 1829, and palm oil, originally used as ship ballast during the African slave trade, was arriving regularly in Cincinnati via the Mississippi.

As the list of products grew, distinctive names were needed. In the case of candles, the identification problem had been solved by shipping clerks who marked the Procter & Gamble crates with crudely painted stars. By 1850 the partnership was calling its brand "Star" candles. Eventually the stars, with a half moon added, were adopted as the trade-mark of the Company. "German" and "Oleine" laundry soaps became well-known brands of Procter & Gamble's red oil soaps. Newspaper advertising of soap brands had been practiced since colonial times. Procter and Gamble were early believers in advertising, and by the time of the Civil War, their products were widely known. Sales were well over $1,000,000 a year.

When the Civil War broke out, Procter and Gamble contracted to supply the Army of the West with soap during the war years. Their factory was the only one permitted to operate in Cincinnati when martial law was imposed due to the threatening activities of Kirby Smith's Confederate raiders on the Kentucky side of the Ohio River. Following the war, Procter & Gamble gained good will and respect by extending credit to many Southern dealers who had lost their capital. For help in managing their expanding business, the partners were now able to

turn to their sons, William A. Procter in the financial side of the business, and James N. Gamble in the production side. Both young men had attended Kenyon College, in Gambier, O., and Gamble had continued his studies in chemistry.

When James N. Gamble entered the plant the lime saponification method of fat splitting was being replaced by the Tilghman autoclave, in which fats were heated with steam under pressure to obtain fatty acids and glycerin. Scheele had first obtained glycerin experimentally in 1779 and called it the "sweet principle of fats." Then Chevreul discovered that fats were compounds of fatty acids and the sweet material, which he named glycerin. This by-product had no great commercial importance, however, until the sixties, when Nobel demonstrated the value of nitroglycerin and dynamite as explosives. With the introduction of the Tilghman process the resulting glycerin was concentrated enough to make its recovery economical.

Most of the outstanding developments in soapmaking during the first decade following the Civil War were, however, mechanical improvements in the production of bar soap. Soapmaking was becoming of greater relative importance to the firm, as the growing use of petroleum for lighting reduced the trade in candles and lard oil. The brands then made included Dutchess, Princess, Queen, German, White Soap, Town Talk, and others, most of them laundry soaps, as toilet soap was still a luxury. Soda ash imported in hogsheads from England had largely replaced potash as a source of lye and was also used as a builder and hardening agent for rosin soap. There was no domestic soda ash industry which could compete with the English lime-soda process. It was not until the introduction of the newer Solvay ammonia-soda process in the United States that this country was furnished with cheap, uniform, and abundant alkali. Other alkaline materials, such as potassium silicate, sodium silicate, and potash were also being added to laundry soaps to increase the yield and to improve detergency. The difficulties of mixing these builders into molten soap stocks brought about the introduction of mechanical mixing or crutching, which led to a discovery that had a far-reaching effect on the fortunes of Procter & Gamble.

The formula for the Company's white soap had been purchased from a man who offered it as similar to castile. It was found that this new soap floated. James N. Gamble soon traced the cause to the mechanical crutchers which were incorporating enough air bubbles into the soap to reduce the specific gravity to the floating point. The market possibilities of the new product were quickly sensed and Gamble established methods for the consistent production of the floating soap. Harley Procter, another son of the original founder, was impressed by the suitability of the word "ivory," quoted in a passage from the Psalms for the new soap. The name was registered in the U. S. Patent Office and the first cake of Ivory soap was sold in Oct. 1879. Analysis of Ivory showed it to be "99-44/100 per cent pure." This result was used in advertising from that time until the present, and is one of the most widely known of all advertising slogans.

National advertising and distribution caused such a demand for increased production that the facilities of the Central Ave. factory were expanded to their limits. When a disastrous fire destroyed a large part of the plant in 1885, the new and larger Ivorydale factory was built seven miles from Cincinnati. Here, for the first time, space was set aside for the specific use of a chemist. Although at first the work consisted largely of factory control tests, studies were begun in the fundamental chemistry of soap; soapmaking was accepted as being a chemical process. In 1890 a successful glycerin-recovery system was installed for the evaporation and distillation of soap lyes.

By this time the firm was managed by the second and third generations.

William A. Procter, Harley T. Procter, James N. Gamble, David B. Gamble, and William A. Gamble, all sons of the founders, were active in the management, and in 1890, when the Procter & Gamble Co. was organized as a stock company, William Procter was named first president. His son, William Cooper Procter, was by that time factory superintendent. Through his instigation the Company introduced a group of employee plans, which were startling innovations at the time, the Saturday afternoon holiday without reduction in pay, and in 1887 a profit-sharing plan. Among other plans which were developed under his guidance, both before and after he became president of the Company in 1907, were a pension and benefit plan and a guarantee of regular employment.

By the beginning of the 20th century, Procter & Gamble was known for its progressiveness in all aspects of soapmaking. Contrary to earlier methods, manufacturing processes were now chemically controlled at every point and raw materials were purchased on specifications. Fat splitting and the purification of resulting fatty acids permitted the utilization of cheap raw materials. Tilghman's autoclave had been outmoded after Dr. Ernest Twitchell's discovery in 1897 of an aromatic sulfonic acid which promotes fat hydrolysis.

To obtain an adequate supply of fat stocks, Company representatives were combing the world's markets. Copra and coconut oil were shipped from the Philippines, olive oil from the Mediterranean countries, palm kernel oil from West Africa, peanut oil from China, whale and other marine oils from the Atlantic and Pacific, and many others—including several vegetable oils obtainable in the United States. Most important of these was cottonseed oil, which had been used since about 1870 in soapmaking and later as a constituent of edible products. Near the turn of the century, in order to assure a satisfactory supply of cottonseed oil, Procter & Gamble organized a subsidiary, the Buckeye Cotton Oil Co. This was also the first step in a program of rapid expansion which led to the construction of soap factories and offices in the United States and in foreign countries, near sources of important raw materials and centers of distribution.

Soon after organizing the Buckeye Cotton Oil Co., Procter & Gamble erected a plant at Ivorydale for making salad oil from cottonseed oil. Shortening manufacturers had been led by the high prices of lard to mix it with cottonseed oil and oleostearin, yielding "lard compounds" with much to be desired in flavor, color, odor, and keeping quality. Early in the 20th century Kayser, working in England, developed methods for the commercial catalytic hydrogenation of various oils and offered his knowledge to Procter & Gamble in connection with the manufacture of both soap and shortening. Following his arrival in the United States, Kayser was granted patents on the catalyst and process. Marine oils hardened by hydrogenation were found to be much improved for purposes of soapmaking because of the absence of odor and the resistance to rancidity; and hardened cottonseed oil was found to have excellent shortening properties which improved the quality of the lard compound mixtures. Further experiments showed that partially hydrogenated cottonseed oil itself was more stable than the shortening mixtures, and in 1911 Procter & Gamble introduced Crisco, the first all-hydrogenated purely vegetable shortening. The advantages of this new type of shortening lay in its superior color, odor, uniformity, and keeping qualities.

Subsequent work in the Company's research laboratories, test bakeries, and kitchen led to the development of a new type of shortening characterized by superior emulsifying properties. During 1934-38 the U. S. Patent Office granted the Company a series of patents covering this development. A new bulk product called Sweetex, incorporating this new development, was offered to the commercial baker and Crisco was changed so as to give the consumer improved baking results.

Since the turn of the century, Procter & Gamble has offered many new soap products. It first deviated from framed soap when it produced a milled, black tar soap about 1900. This was shortly discontinued and it was not until 1926 that milled soap production was started on a large scale with the introduction of Camay. In 1904 Procter & Gamble offered Star soap powder, after acquiring the brand from the Schultz Soap Co. of Zanesville, O. This type of product was a mixture of mechanically powdered soap with added detergents and had first become popular in the latter part of the 19th century when the establishment of the American soda ash industry furnished a source of cheap alkali.

With the growth of the commercial power laundry industry and its need for a quick-dissolving soap, soapmakers had produced soap in chips which dissolved faster than bar soap but not as fast as desired. In 1909 Procter & Gamble installed new soap-processing equipment for producing soap flakes. Amber Flakes, White Crown, and Ivory Flakes were made for commercial laundries and when household laundry machines were introduced, Chipso and other flake soaps were also produced. The demands of housewives for a still faster dissolving soap were met by the development of a technique for making soap granules. In 1926-27 Procter & Gamble, together with Colgate-Palmolive-Peet, obtained the basic Holliday and Lamont patents for atomizing and drying liquid soap in a sprayer tower. Ivory Snow, Duz, and Oxydol are made by this process. Elimination of lime-soap scums resulting from the reaction of soap with hard water, was solved in 1931, when Procter & Gamble obtained rights to the use of the discovery of Deutsche Hydrierwerke and Boehme Co. chemists—production of synthetic sudsing detergents. An entirely new line of detergents followed: Gardinol, Orvus, Dreft, Drene, Teel, etc.

In addition, Procter & Gamble has pioneered continuous processing methods on which, beginning with 1939, a series of patents have been granted. Here even closer control of quality is possible and the soapmaking process is many times faster than the old kettle method, takes less space, involves a much lower inventory of material in process, and permits higher glycerin recovery. The first step in the new continuous method of soapmaking is a continuous fat-splitting process which takes place in a stainless steel, high-pressure tower or hydrolyzer. Heated fats and catalyst enter the column at the bottom and preheated water at the top. Glycerin and water are continuously drawn off at the bottom of the column and fatty acids at the top.

Continuous crutching in high-speed mixers instead of in large-batch crutchers has also been introduced, and a quick method of cooling and whipping soap stock in freezers has been developed. Another process patented by the Company in 1940 makes possible the continuous sulfation of fatty alcohols in the production of synthetic detergents. A directive by president William Cooper Procter in 1921 facilitated the growth of these and many other notable contributions and investigations, by separating the functions of research and factory operation.

During World War II, the Procter & Gamble Defense Corp., organized at the Government's request, built and operated the Wolf Creek Ordnance Plant at Milan, Tenn., and the Gulf Ordnance Plant at Prairie, Miss., for the loading of shells and bombs. In addition, Company officials contributed their time to assist various wartime agencies. For example, R. R. Deupree, president of Procter & Gamble Co. since 1930, was chairman of the Business Advisory Council of the Secretary of Commerce, and chief of the Agricultural & Forest Products Division of the War Production Board.

With the end of the war, the Company has again turned its full attention to the task of maintaining its position in the highly competitive, yet relatively stable, soap and shortening industry.

PUBLICKER INDUSTRIES INC., was incorporated in Pennsylvania in 1913, under the name of Publicker-Ward Distilling Co., by Harry Publicker, John B. Ward, and Martin J. Weinstein. Its name was changed in 1919 to Publicker Commercial Alcohol Co. and in 1945 to Publicker Industries Inc. The Company's principal office is at 1429 Walnut St., Philadelphia.

The first activity of the Company was the production of ethyl alcohol by molasses fermentation at a plant at Snyder Ave. and Swanson St., Philadelphia, and its sale in pure form and denatured for industrial purposes. In 1924 a second plant at Bigler St. and Delaware Ave. was added, which has subsequently been expanded both as to molasses ethyl alcohol and numerous other products and is now the largest plant of the Company.

Upon the repeal of Prohibition in 1933, the Company, through subsidiaries, entered the distilled spirits business, producing, warehousing, rectifying, bottling, and distributing branded lines of whiskies, gins, and other spiritous beverages. Whisky and neutral spirits have also been sold in bulk. With the large-scale production of distilled spirits and alcohol from grain in recent years, production of distillers' dried grains was expanded and that of dried solubles from grain-fermentation residues undertaken. These products have been distributed to the livestock and poultry feed trade.

Publicker's business may be divided into two principal lines—industrial chemicals and alcoholic beverages, and, in connection therewith, distillers' dried grains and solubles. Through a subsidiary the Company purchases molasses direct from producers in Cuba, the Philippine Islands, and elsewhere; has facilities for its handling and storage; and is engaged in the shipping business, being associated in the ownership and operation of ocean tank vessels.

Among the products and branded lines included in the industrial chemical group are: Products—ethyl alcohol, acetaldehyde, acetic acid, acetone, anti-freeze, butyl alcohol, butyl acetate, distillers' dried grains and dried solubles, dry ice, liquid carbon dioxide, ethyl acetate, fusel oil, aldol, amyl alcohol, and amyl acetate. Brands—Paco (industrial solvents), Thermo (anti-freeze), Alco-Wash (rubbing alcohol), Pharmco (pharmaceutical alcohol), A-sep-aco (medicated alcohol).

The Company and its subsidiaries have the largest ethyl alcohol-producing capacity in the United States and are major producers of a number of the above-mentioned products. In Jan. 1946 the Company produced approximately 3,200,000 proof gal. of ethyl alcohol, or approximately 13.6% of the national production.

The directors and officers of the Company are: Harry Publicker, chairman and director; S. S. Neuman, president and director; Charles P. Blinn, Jr., C. L. Gabriel, W. J. Lehman, and L. H. Marks, vice-presidents and directors; Charles Kurz, vice-president; L. J. Gunson, secretary-treasurer and director; A. P. Fenderson, director; A. E. Lang, assistant secretary; and J. Maurice Gray, director and general counsel for the Company and its subsidiaries.

PYRIDIUM CORPORATION was organized by Louis A. Van Dyk and William S. Lasdon in 1925, with offices and Research Laboratories in Nepera Park, Yonkers, N. Y., for the manufacture of pharmaceutical chemicals and chemical intermediates. With Dr. Iwan Ostromislensky as director of research, the Corporation undertook the investigation of pyridine and its derivatives and the first development was phenyl-azo-α,α-diamino-pyridine monohydrochloride, a coal-tar derivitive sold under the trade name Pyridium, which was a new advancement in the treatment of urinary infections. Numerous other chemicals and intermediates

were developed and thereafter manufactured, especially among the pyridines for which uses were found in chemical manufacturing and generally for research purposes. Pyridium later sold in more than 30 countries and the Corporation continued to enlarge its research facilities, staff, and production facilities toward the development of new and useful chemicals.

In 1933 Rare Chemicals, Inc., was organized in association with Boehringer & Soehne, Mannheim, Germany, for the manufacture and sale in the United States of such pharamceutical proprietaries as Salysal, Eucupin, Optochin, and Arsenoferratose. In 1939 Pyridium Corp. sold its interest in this enterprise. When Louis Van Dyk retired from the Corporation in 1936, his interest was purchased by William S. Lasdon, who was thereafter elected president and has continued in that capacity.

The Corporation has been especially identified with the production of 2-aminopyridine, the basic chemical in the manufacture of sulfapyridine. It has researched the development of this sulfa drug, especially indicated in the treatment of pneumococcic infections, as well as of 2-sulfanilamidopyrimidine or sulfadiazine. During World War II, sulfadiazine, which is less toxic than other sulfonamides, played an important role in the treatment of diseases in the Armed Forces.

In 1939 Nepera Chemical Co., Inc., a subsidiary of Pyridium Corp., was organized for the sale of methenamine mandelate, a new remedy for urinary infections, under the trade name Mandelamine. In addition, other proprietaries of the Corporation were distributed to physicians through this division, especially Neohetramine, an important antihistaminic prescribed in allergy. A Sales Division was established also for the promotion of pharmaceutical specialties. In 1942 Pyridium Corp. founded the Harriman plant at Harriman, N. Y., employing commercial processes developed in its Research Laboratories for the large-scale manufacture of two important vitamins, niacinamide and niacin. The Company is the most important producer of niacinamide in the world. This plant was further enlarged during the war years. In 1945 Nepera International Corp. was formed as an additional exporting subsidiary of Nepera Chemical Co. Its head is Stanley S. Lasdon and M. S. Lasdon is a director. Foreign agencies have been established in the important countries for its own and other products.

The present board of directors and officers of the Corporation are: William S. Lasdon, president; Stanley S. Lasdon, director, vice-president, and secretary, in charge of all sales, pharmaceutical advertising, and labor management; Dr. Edmond T. Tisza, director and vice-president, in charge of coordinated research and engineering; Milton S. Lasdon, director and vice-president, in charge of production in both the Nepera Park and Harriman plants; and J. S. Lasdon, director and treasurer. They have all long been associated with the pharmaceutical and chemical industry, and as individuals each has contributed greatly to the success of the business. Stanley S. Lasdon is also director, secretary, and treasurer of Nepera Chemical Co.

Stanley S. and J. S. Lasdon have been with the firm since 1934, Milton S. Lasdon since 1936, and Dr. Tisza, approximately 20 years, during which time he has become especially identified with the developments of sulfapyridine and sulfadiazine. Dr. John V. Scudi, formerly assistant professor of pharmacology at the College of Physicians & Surgeons, Columbia University, is the director of research for the Corporation, which maintains a fully staffed Engineering Department. The Lasdon Foundation, Inc., a charitable organization, is one of the many activities of the Lasdons. Its president is Wm. S. and secretary, Stanley S. Lasdon.

Pyridium Corp. today is engaged in an expansion program for the synthesis, development, and manufacture of new chemotherapeutic chemicals. Through its

Research Laboratories, Bacteriological Departments, and Analytical Departments, which comprise more than 30 chemists and engineers, its program is to make available new chemical and pharmaceutical drugs for the treatment of diseases and to maintain the high standards to which the original founders were dedicated.

QUAKER OATS COMPANY traces its origin to the first oatmeal mill in this country at Akron, O., which began operations in 1856. In the 1860's John Stuart, born in Scotland, grandfather of the present two chief executives of the Company, purchased an old sawmill near Ingersoll, Ont., Canada, and converted it into a grain mill. As the Company grew, its plant at Cedar Rapids, Ia., became its principal mill, and is today the largest cereal mill in the world. Here many carloads of oats, wheat, barley, rye, corn, rice, soybeans, and other agricultural products are daily processed and converted into a wide variety of food products for man and beast. An important adjunct is the plant for manufacturing furfural. It was originally operated to utilize more profitably the large quantities of waste oat hulls.

The Stuart brothers are responsible for the original decision to go into furfural and, through an initial decade "in the red," for the continued support which made possible this unique development. John Stuart, now board chairman, and R. Douglas Stuart, vice-chairman, have fully justified their faith in the chemical venture, and with Donold B. Lourie, now president, are giving furfural every opportunity to fulfill its destiny. Furfural celebrated its silver anniversary as a commercial chemical in 1947. Feb. 27, 1922, the first 55-gal. drum of furfural was filled by Harold J. Brownlee at the Cedar Rapids plant of Quaker Oats. The contents of this drum filled a number of orders at $2.50 per lb. Over 50,000,000 lb. of furfural are now sold annually, at 9½¢ per lb. in tankcars.

How a leading food manufacturer got into the chemical business is another success story which began with an experiment that failed. At the close of World War I, a shortage of molasses used as an ingredient of stock feed led the Company into research directed at the production of wood sugars from oat hulls. The Miner Laboratories of Chicago, under the active direction of Carl Miner, started in 1919 the work which was to have such important long-range results. Initial effort was to improve the feeding value of the oat hulls by an alkaline treatment. In June 1920 Harold J. Brownlee of the Miner Laboratories took charge of the research, trying acid hydrolysis. Traces of furfural were found in the vapors from the digestion, which started a side-line interest, and Brownlee prepared the first laboratory sample of furfural from oat hulls in the spring of 1921. Laboratory work in Chicago was transferred to semicommercial operations at the Forest Products Laboratory during the summer of 1921, when 300 lb. of hulls were hydrolyzed at a time to determine the yield of sugars. In Nov. 1921 the work was expanded to 4,000-lb. quantities of hulls at Cedar Rapids, for the production of an improved stock feed. Fortunately, the "blow-off" vapors were collected, condensed, and the liquor shipped to Chicago, from which several hundred pounds of furfural were recovered.

Two years' work resulted in an improved stock feed, except that the cattle found it unpalatable and that phase of the project was terminated, when Carl Miner said, "Let's make a 100% material balance and find out what the missing 20% is." Attention was focused on the furfural which amounted to about 10% of the original oat hulls. Enough was known even then to realize that this had great potentialities and a survey was started into its possible uses. Prior to War I furfural was imported from Germany at $1.50 an ounce in one-ounce bottles. One of Miner's

chemists estimated that oat hulls currently available at Cedar Rapids were worth $5,000,000 per year. Unfortunately about one ton could supply the then-existing world market for furfural. Early in 1922 Miner recommended exploration of marketing possibilities, coupled with continued application research for furfural. Quaker Oats approved this recommendation, although it seemed far from the cereal business, and was its first excursion into a foreign field. It was subsequently discovered that raw oat hulls had more value than originally supposed, and they have commanded a high value in stock feeds to this day, but the commercial development of furfural was under way.

With the production of the first barrel of furfural at Cedar Rapids, the Miner Laboratories undertook market development work and acted as sales agents for a number of years. Carl Miner talked at section meetings of the American Chemical Society and at various schools and colleges. Early advertising helped tremendously. All this publicity brought a flood of requests for samples. A leading chemical industrialist said, "If you can ever get the price down to 50¢ a lb., it will have a big use." Before the end of 1922 furfural was sold in drum lots for as low as 40¢.

Furfural, later to engage as a full-fledged soldier in World War II, had been a cadet in the First World War. Vanderveer Voorhees (now a patent attorney for Standard Oil of Indiana) was then at the University of Illinois working under Roger Adams and C. S. Marvel. During 1917-18, he made furfural at the rate of 5-10 lb. per week for two years. Rumor has it that furfural was required as a special wartime chemical reagent at about $5 per lb. Voorhees chose for his raw material corncobs which he ground and charged into 10-liter flasks.

Carl Miner tells that in the early 1920's they expected furfural to sell principally in the form of derivatives, of which many examples were prepared. Many years passed before the derivatives assumed commercial importance, for furfural itself soon found so many uses that it was then, and still is, sold principally as such. Even though few furfural derivatives found immediate commercial use, their mere existence served to illustrate the versatility of furfural as a reactive chemical. They catalyzed interest and inspired others to work.

The customers found the uses. At first, the greatest commercial interest was in furfural as a resin-former, notably in combination with phenol. Some was sold as a weed killer, particularly to railroads, and in the form of a mercury salt as a fungicide for seed treatment. Though data on furfural needed by customers was furnished, as well as information on handling, little or no effort was made to show the customers how to use furfural, as in those days it was still common for a customer to know more about his uses than the supplier. Among those first customers in 1922 were du Pont, Durite (Stokes & Smith Co.), Eastman Kodak, Bakelite, Ault & Wiborg, General Electric, Monsanto, and B. F. Goodrich, names still on the active customer list. Still another was Dr. Frank C. Whitmore, then at Northwestern University, and the late Dr. L. V. Redman bought furfural for one of the early Redmanol resins. Meanwhile Brownlee was wrestling with production problems at Cedar Rapids, not the least of which was corrosion. He worked out a low liquid-solid ratio effecting important steam economies. The patent record speaks eloquently of his continuing contributions to the development of an efficient and economical process.

The "extrapolated price policy" has been extolled by many, if not as widely adopted. Quaker Oats Co. practiced it on Miner's advice in the early 1920's. That is, it was willing to reduce the price of furfural below then-existing actual costs in order to get sales volume. In 1926 the price of furfural dropped to 17½¢ per lb. in drums. The first tankcar made was shipped in Apr. 1928 to the Hercules Powder Co., for refining crude FF grade wood rosin to a light-colored product

capable of competing with gum rosin. Independently, the Texas Co. developed its unique and successful process for the solvent refining of lubricating oil. Then the Pittsburgh Plate Glass Co. applied furfural solvent refining to linseed oil and other vegetable and animal oils, yielding drying and semidrying oils with improved characteristics.

In 1925 Miner employed a young chemist, Fredus N. Peters, Jr., a University of Wisconsin Ph.D., who six months later took charge of furfural sales development work. With tankcar production under way in 1928, Brownlee and furfural production were transferred by Miner to Quaker Oats. Technical sales work, however, continued with the Miner organization under Dr. Peters' leadership until Feb. 1, 1931, when this function was also transferred with him to Quaker. The price of furfural in tankcars was reduced to 9¢ per lb. in 1930.

A fundamental change was brought about by the demands of World War II. The huge synthetic rubber program required large quantities of butadiene and the leading method for refining butadiene is the extractive distillation process using furfural. With other wartime demands in solvent refining, in synthetic resins, as wetting agent and solvent in resinoid-bonded grinding wheels, and miscellaneous ways, there was in total a nearly fivefold increase in furfural consumption, and it went on allocation by the War Production Board as a critical chemical. This was paralleled by demands for oat hulls as a component of stock feeds, where they have a value beyond that of a furfural raw material. New agricultural raw materials high in pentosans had to be found quickly, among which corncobs, cottonseed hulls, and rice hulls occupied an important position. The procurement of raw materials for furfural independently of the cereal business became a major undertaking, and the effect of the war was to change furfural from a by-product operation into an independent primary manufacture from natural raw materials whose availability is virtually unlimited.

In 1942 the Reconstruction Finance Corp., Office of Rubber Reserve, entered into an agreement with Quaker Oats under which its processes and experience were made available in connection with the design, construction, and operation of a plant at Memphis, Tenn., to produce 24,000,000 lb. of furfural per year. A subsidiary, the Q. O. Chemical Co., was formed to undertake this war mission, ground was broken in Oct. 1942, and the plant began production nine months later. It operated until Nov. 1, 1946, when it was purchased from the Government by Quaker Oats. This new capacity brought forth a number of new uses for furfural, and in less than a year, the output of the original plant was in use, leading to a substantial expansion at Memphis in 1947 and plans for the expansion at Cedar Rapids.

During the first 25 years of furfural's existence, by far its largest use was as a selective solvent. It is now coming into its own as a reactant valued for its chemical characteristics instead of its physical properties. Development to the commercial stage of a process for the production of a principal intermediate of nylon from furfural is the latest of many remarkable achievements in the history of furan chemistry. Hydrogenation of this intermediate, adiponitrile, to hexamethylenediamine is followed by reaction with adipic acid and subsequent processing into filament, bristle, sheet, molding material, or other form ready for fabrication. Research workers at du Pont are responsible for developing the series of steps by which furfural is converted to adiponitrile, a truly amazing story of synthetic organic chemistry.

Earlier work on hydrogenation by Dr. Peters and others resulted in the first commercial shipments of furfuryl alcohol in 1934, and tetrahydrofurfuryl alcohol in 1939. The use of these alcohols in industry has grown steadily and both have

been tankcar items for several years. Increasingly important use is being made of furfuryl alcohol in highly resistant coating and casting resins and impregnating compositions. Moreover, it is proving to be a more versatile resin-former than furfural, and an interesting new series of resins is coming to light in which furfuryl alcohol is copolymerized with various amines, phenol, thiocyanates, aldehydes, and other compounds. Tetrahydrofurfuryl alcohol is useful where special solvent properties are required, and more especially in the form of its esters for plasticizers. Furoic acid is now being manufactured in pilot-plant quantities by a new method.

In the process of extracting from agricultural residues the pentosans and converting them to furfural, large tonnages of by-products are formed, amounting to approximately three-fourths of the weight of original raw material. Most of this leaves the process in the form of spent oat hull, corncob, and other residue, and for many years was burned as a secondary fuel for steam generation. It is an excellent conditioner for mixed fertilizers and increasingly large amounts are used in this industry. Further processing of this residue into a dry flour-like material has value in such fields as plastics and foundry core compositions. A few carloads per month of by-product low-boiling solvent consisting of methanol, ketones, and aldehydes, are produced and sold. Consideration is being given to the possibility of recovering some acetic acid, also produced in the furfural process.

The Chemical Research Department of Quaker Oats, now headed by Peters as vice-president, includes an active and growing division working on furan under the leadership of Andrew P. Dunlop. They are continuing on an expanded scale to extend the boundaries of furan chemistry, to develop new and improved applications in many fields, and to develop better and more economical manufacturing methods. Out of this work are coming new furfural derivatives, including hydrofuramide, sodium furoate, and methylfuran. One of their chief purposes is to assist in the utilization of furfural as such, and as a chemical intermediate. Exploratory research in synthetic resins is facilitating the development of new furan resins, and is a good example of the general research work undertaken by the Company to assist its customers. It is extremely unlikely that the Company will ever go beyond a few "first generation" derivatives like those it is now marketing. Patents obtained are for the sole purpose of keeping the field open to all who may be interested in these applications of furan chemistry. Additional research is being supported at several educational institutions.

Thus, although furfural has been known for 114 years, the chemical and industrial knowledge of the furans has really just started to develop in the past 20 years, perhaps even in the past decade. So interesting have these developments been that it led a famous American professor to remark that in the next 20 years the progress of furan chemistry would rival the advances made during the past 70 years in benzene chemistry.

Recognizing the inevitable growth that lay ahead, Quaker Oats in Aug. 1944 combined its several chemical activities and organized the Chemicals Department located at the Company headquarters in Chicago. It is headed by Dr. Lauren B. Hitchcock, vice-president, assisted by Dr. Homer R. Duffey and Frank F. McKinney, sales manager. The plant at Cedar Rapids has for many years been under the immediate technical direction of Dr. Henry P. Howells; Russell W. Kirn is general manager of the Memphis plant, assisted by Charles M. Holmes. Warehouse stocks are carried at Waverly, N. Y., and Los Angeles. The Eastern sales office is in N. Y. City, while foreign sales offices are maintained in London, Rotterdam, Paris, and Sydney, Australia.

REICHHOLD CHEMICALS, INC., with 12 modern plants representing the largest business of its kind in the world today, started in a two-car garage at the rear of a Detroit city lot in which RCI began experimenting with synthetic resins for the surface-coating industry back in the spring of 1925. Two years later, actual manufacture began in a small single-story building located on the site now occupied by the Reichhold main plant and general offices—a tract of 12½ acres lying on both sides of the Grand Trunk railway tracks in Ferndale (Detroit).

Twenty-two years have elapsed since Henry H. Reichhold, now chairman of the board of Reichhold Chemicals, Inc., reached the conclusion that synthetic resins offered a means of producing superior surface finishes of predictable quality. His vision of the future for synthetics materialized to a degree even beyond his fondest hopes. During these years, Reichhold plants here and abroad have been added in the following order: 1933, Liverpool; 1935, San Francisco (destroyed by fire and rebuilt in 1943) ; 1936, Paris; 1936, Elizabeth, N. J.; 1938, the 50-year-old business of the Fred L. Lavanburg Co., chemical color manufacturers, Brooklyn, N. Y.; 1939, Sydney; 1943, Tuscaloosa, Ala.; 1946, Seattle; and 1947, Zurich, Milan, and Rio de Janeiro.

Any RCI resin plant might be described as a very large laboratory with manufacturing operations attached, where production is measured in terms of carloads per day. The laboratories are crucial because they touch and control operations in every step of RCI's manufacturing processes, whether the end product is an alkyd, a maleic, a phenolic, a melamine, or a urea-formaldehyde resin.

One group of RCI chemists exercises close control over every step in the Company's manufacturing operations. A spoiled batch of synthetic resin stays spoiled. The fact that other manufacturers will use the resulting resins, sometimes under conditions which cannot always be anticipated or controlled, places a double responsibilty on RCI to see to it that quality and specifications are kept within extremely narrow limits. A second laboratory group mans miniature manufacturing establishments, whose job it is to use RCI synthetics in the making of surface coatings, paper, laminates, textiles, etc., just as the manufactures of these end products will use the resins in actual production. This group must prove that these various RCI synthetics will fill the roles for which they were developed. A third laboratory group is the technical research organization, composed of graduate chemists, whose task is not only to keep pace with the demands of RCI customers, but also to anticipate these needs. This assignment includes keeping up with current scientific developments, formulating new synthetics, testing them, and patenting formulas that appear to have market possibilities.

Since 1925, RCI's laboratories have conducted a never-ending investigation directed toward the improvement of surface-coating materials via the discovery, development, and application of new, different, and better synthetic resins. Their efforts have been successful and the major portion of the Company's alkyd, pure phenolic, modified phenolic, and maleic resins; ester gums; synthetic oils; and processed copals still goes to the manufacturers of paints, varnishes, lacquers, and printing ink. A more recent development, RCI phenolic plastic resins are in constantly increasing demand for bonding fibrous materials, such as paper, canvas, asbestos, glass fiber, etc.; to build up phenolic laminates; and also for bonding woods to produce plywood of extreme water resistance.

RCI's water-soluble urea-formaldehyde resins are popular with textile, paper, and furniture manufacturers. The textile industry employs them as "dimensional stabilizers" and crushproofing agents. Paper mills use them to increase the wet strength of papers, to improve the wet-rub of starch-clay paper coatings, and to

add to the water resistance of starch adhesives. Urea-formaldehyde resin adhesives have achieved acceptance in the furniture and plywood fields, largely due to their water resistance, as compared with protein-type glues.

In addition to its synthetic resin manufacture, RCI, with its original color plant at Brooklyn and a new unit at Tuscaloosa, has become a major producer of chemical colors. RCI's Southern Division at Tuscaloosa is also a large producer of phenol and heavy industrial chemicals.

REILLY TAR & CHEMICAL CORPORATION is the story of its founder, Peter C. Reilly, Sr. Born in Providence, R. I., where he attended De La Salle Academy, Reilly is a product of American training and the American system of free enterprise. Through his determination and aggressiveness, and continued study under private instruction, there has resulted an unique organization in the coal-tar chemical industry. In 1886 Reilly became associated with the Mica Roofing Co. of New York, one of the original coal-tar distillers in the United States, which subsequently purchased the Western Chemical Co. at Indianapolis. He was appointed manager of that business in 1895, and moved to Indianapolis. Later Reilly purchased the Western Chemical branch of the business and in 1900 set up his own operation which was subsequently known as the Republic Creosoting Co., of which he is still president.

The business originally was tar distillation for production of creosote oil and pitch. The oil went into Republic's creosoting operations which then included a large volume of creosoted wood block for street pavement and factory flooring. The Republic business expanding, plants were established for tar distillation and creosoting at Minneapolis and Mobile; later at Norfolk, Va., Provo, Utah, and Seattle. In 1920 the Indianapolis plant was moved to a new 80-acre site with installation of most modern creosoting and distillation equipment.

Realizing the importance of developing new chemical products from coal tar, Reilly established in 1919 a chemical and metallurgical research division and by 1930 had built a separate research building, the Reilly Laboratories, on property adjacent to the Indianapolis plant. Republic Creosoting was regularly producing paints and protective coatings, as well as such coal-tar chemicals as anthracene and carbazole, which had never before been manufactured in the United States. In 1932 Reilly purchased the tar and chemical plants of International Combustion Tar & Chemical Corp. located at Newark, Fairmont, W. Va., Dover, O., Chattanooga, Granite City, Ill., and Chicago. These plants were consolidated with the Republic Creosoting's chemical operations into the Reilly Tar & Chemical Corp. In 1936 a tar-processing plant was built in Cleveland and in 1941 at Belle, W. Va. In 1938 a new and modern creosoting plant was added at Lima, O. The Reilly operations thus range from Seattle on the West Coast to Newark and Norfolk on the East, and from Minneapolis in the North to Mobile in the South.

An early invention created by Reilly was complete distillation of tar to a carbon residue in a metal still in one operation. This process not only gave the usual products from the tar, but also made available (as was reported in the current German press) a new, valuable, and unusual series of chemical compounds. It also gave the industry the purest commercial form of carbon known as Reilly Carbon, which became in 1922 the raw material for an affiliate Reilly company, Char Products Co., whose principal product is case-hardening material. Reilly Carbon has been continuously used in the abrasives industry for production of silicon carbide and is also a base carbon for the manufacture of electrodes.

Since the establishment of the Reilly Laboratories, the Reilly Corp. has continuously increased the scope of its activities in the coal-tar field. All of the

regular coal-tar intermediates of importance to industry have long been produced and research has added many new coal-tar materials. Among these is 2-vinylpyridine, developed during the war, which has yielded a product more nearly resembling natural rubber than any other synthetic elastomer.

Reilly coal-tar chemicals embrace the acids—phenol, purified cresols, xylenols, as well as the standard acid blends; bases—pyridine, α-picoline, β-picoline, γ-picoline, 2,6-lutidine, quinoline, acridine, quinaldine, as well as derivatives of these materials such as 2-aminopyridine and 2-vinylpyridine; hydrocarbons—acenaphthene, anthracene, carbazole, chrysene, fluoranthene, fluorene, methylnaphthalenes, naphthalene, phenanthrenes, and their derivatives. Other Reilly products include road-paving tars, carburizing compounds, standard-specification creosote oils, Transote (a colorless, greaseless, and odorless wood preservative), disinfectant oils, pickling inhibitors, all varities of pitch including briquette, electrode, fuel, paving, roofing, target, and waterproofing pitch, Plastuvia crack filler, roofing felts, pipe-line enamels, pipe-dip compound, coal-tar paints, phenolic molding powders, and synthetic resins.

RESEARCH CORPORATION, a unique enterprise, was brought into being in 1912 through the vision of Dr. F. G. Cottrell. It was founded on the basis of gifts of valuable rights in his patents in the field of electrical precipitation. The Corporation's charter requires that its net earnings be contributed to the Smithsonian Institution and such other scientific and educational institutions and societies as the board of directors may from time to time select, to enable such institutions and societies to conduct technical and scientific investigation, research, and experimentation. The Corporation's capital stock cannot bear dividends. Survival of the ideal is tribute to the practicability of the concept. The major achievements of modern science are interspersed liberally with projects in whose development Research Côrp. has participated. A random selection, for example, includes the cyclotron, the Van de Graaf high voltage and X-ray equipment, utilization of solar energy, computing machines, the synthesis of vitamin B_1, pantothenic acid, etc.

Dr. Cottrell's valuable patent rights in electrical precipitation were essentially Research Corp.'s sole asset at the time of its founding and of necessity its early activities were limited to the development of this new method of gas cleaning. As acceptance of electrical precipitation became more general, funds over and above actual operating expenses accumulated from the sale of such installations and the Corporation was enabled to give attention to the basic purpose for which it was organized. These activities were concerned initially with granting funds to appropriate institutions in support of fundamental research, but in the natural course of events soon included the management of patents and new inventions donated or shared by individuals and institutions. As a result, there have evolved three divisions of Corporation activities: Division for Engineering & Construction, concerned with the design, manufacture, installation, and sales of electrical precipitation equipment; Division for Patent Management, concerned with the establishment of agreements with individuals and institutions for the commercialization of patents and development work on new projects; Division for Grants, concerned with granting funds in support of scientific research and the developing and conducting of relationships for the advancement of science and technology with educational and scientific institutions.

The Corporation started its career by interesting certain industrial companies—particularly metallurgical and chemical companies—in the application of electrical precipitation to their gas-cleaning problems. Originally it simply issued licenses

on a royalty basis and rendered engineering services on the design of the equipment, which was constructed by the licensee, and furnished an engineer to supervise the erection of the installation and the tests on its operation. Under this procedure the Corporation assumed no responsibility for the successful performance of an installation. Beginning about 1918, the Corporation started to contract for the design, furnishing, and erection of such installations with definite guarantees on their operations. Under this method of doing business, a number of installations were made and proven in, with the result that electrical precipitation gradually became accepted by many basic industries as a standard method of gas cleaning.

Ranging from abatement of smoke nuisance to the recovery of valuable chemicals from vapors, the applications extend into the smelting and sintering industries, to blast furnaces and steel mills, and to the collection of pigments and precious metals. New applications appear quite frequently and the development of equipment suitable to make them practicable is a continuing job. In pursuing these activities, the Engineering & Construction Division has become a substantial enterprise and has always been the primary source of the funds supporting the Corporation's grants. For many years it was the sole source of revenue, and for nearly 35 years the earnings of the Precipitation Department have supplied more than two-thirds of the funds granted to support scientific research. The high value of the Cottrell patents is evident in this record. Also implicit in it is the fact that until the precipitation art had gained adequate industrial acceptance, the personnel of the Corporation was of necessity almost entirely occupied with this field of work.

A major service to institutions and inventors is rendered by the Corporation's Division of Patent Management. Equipped and staffed to undertake the introduction and commercialization of new inventions, this group is prepared to relieve individuals and institutions of the highly complicated patent management problems. The direct benefits to inventors are illustrated by the classical stories of the tribulations of the lone inventor. The benefits to institutions are readily apparent in the limitations imposed usually by their primarily educational objectives and sometimes by their charters. Working under a predetermined agreement in each case, the Corporation, through this division is peculiarly able to manage new developments to the best interest of the public, the inventor, the institution. This activity has been a factor of growing importance in the discharge of the Corporation's primary responsibility.

From time to time, scientific research brings forth a new invention whose product, use, or availability is so fraught with public interest or welfare that close safeguards must be established. Narcotics and blood plasma, for example, fall in this category. Research Corp. has become the repository of various inventions of this nature, rendering in some cases a cost-free public service of management to control quality of product and to assure proper diligence in production by licensees to serve the best interests of the public. The synthesis of vitamin B_1 is a classic example. These patents, which were acquired from the inventors in 1936, were licensed immediately for manufacture by several chemical firms. There have resulted mass production techniques which have provided the requirements of a low-priced, high-volume sales market. While effecting this, the sales price of synthetic vitamin B_1 was reduced more than 98% in a decade, and quantities of this nutritional requirement made available to the world.

Nearly every invention handled under agreement with Research Corp. has had some facet of particular or peculiar interest. Each agreement with an institution or with an inventor has its provisions established in accordance with the institution's policy or with the inventor's wishes, with the one common proviso that the general public interest must be served when it is affected. Investigation of each

case indicates the practical way of serving these interests, whether by licensing or by organization of a new commercial enterprise. Each license is drawn in such a manner as to facilitate the introduction of the particular invention into wide public use, and to meet the special problems of the particular licensee.

REXALL DRUG COMPANY, today the largest drug products manufacturing and distributing company, was the idea of the late Louis K. Liggett. While a boy in Detroit, he applied the factory-to-retail principle in the dry goods business and at 26, while a salesman for a large drug company, conceived the basic principles on which Rexall was founded and operates. He found that many druggists had their favorite formulas which they made and sold for their own stores under their own trade-marks. Liggett conceived the idea of uniting these druggists, picking their best formulas, and manufacturing them cooperatively to all. In 1902 he enlisted 40 leading independent druggists in his idea of cooperative drug manufacturing and merchandising. The trade-mark Rexall was coined for Liggett by his office boy, Walter J. Willson, who retired from the Company Jan. 1, 1947, by combining the Latin word "Rex" and the English word "All," to signify "King of All."

The Company that started by manufacturing four different drug items now has over 5,000 different articles. Heading the Rexall Co. is Justin W. Dart, 40 years old, who originated the Rexall plan known as "Opportunity Unlimited," which makes possible super-drugstores under independent ownership. This cooperative idea gives every independent druggist who holds a Rexall franchise the facilities and strength to compete successfully against any organized competition, chain or otherwise. Dart believes in the opportunity of every businessman to succeed in his own business, be it a curbstone stand or a factory, and has set out to demonstrate that big business and small business can form a working partnership that will strengthen both and stimulate free enterprise. "Opportunity Unlimited" places independent Rexall stores on a common footing with Rexall's own retail outlets. This has been made possible by unification of the resources, experience, and mass purchasing power of all Rexall organizations, teamed behind every retail unit in the system. Rexall is to the American public a symbol of high-quality merchandise and the world-wide symbol of an organization noted for its spirit of cooperation.

ROHM & HAAS COMPANY was organized to make and sell a new product called Oropon. In 1903 Otto Röhm, a young German chemist starting his industrial career, became interested in preparing a synthetic bate. From time immemorial, this important step in tanning leather had been done in infusions of bird or dog dung, naturally a filthy operation. Many able chemists had sought to learn what changes took place in the hides during the dung-bating operation, and how the same result might be accomplished in a more sanitary manner. Dr. Röhm devoted four years to conducting thousands of experiments and confronting repeated discouragements, but his patience succeeded in preparing a bating material that was both scientific and sanitary. It was named Oropon and in 1907 the partnership between Röhm and his friend and associate, Otto Haas, was formed to manufacture and sell it.

In 1909, after Oropon was established among the tanners of Europe, Otto Haas returned to America, where he had worked formerly, to establish the manufacture and sale of Oropon in this country. Manufacturing operations were begun in a modest way, first in Chicago and then in Philadelphia. In 1916 ground was acquired near Bristol, Pa., on the Delaware River, and the first building of what is now the Bristol plant of the Rohm & Haas Co. was erected.

The Company devoted its efforts in the 1920's to extending the scope of its business into new fields through the development of new chemical products. These included mordants for dyeing leathers, synthetic tanning materials, and better leather-finishing materials. Leukanol, a synthetic tanning material, together with Orthochrom and Primal, synthetic finishes, appeared among the Company's growing list of leather chemicals.

Two important chemicals which became unavailable during World War I were sodium hydrosulfite and sodium sulfoxylate—essential materials for dyeing and otherwise processing textile products. Rohm & Haas decided to provide a domestic source of supply for these chemicals. Lykopon, as the sodium hydrosulfite was called, was long the only powdered reducing agent for vat dyes in the country, and it maintains a position of leadership in the textile industry today. It brought the Company into close touch with the textile industry and the further development of textile chemicals. Among the products are synthetic surface-active agents based on arylalkylpolyether alcohols, and known as Tritons; urea-formaldehyde resins, called Rhonites, used in resin-finishing processes; and aqueous dispersions of acrylic resins, known as RHoplexes, which are also used in treating textile materials.

Oropon, the original product, was based on the use of enzymes, and probably represented one of the first industrial applications for these biologically produced chemicals. As the chemical industry developed, however, new uses for enzymes were found, and Rohm & Haas expanded its research and manufacturing operations in the field. The Company now manufactures industrial enzymes for a wide variety of applications, including fruit juice clarification agents trade-marked Pectinols, starch modifications for the paper trade called Rhozymes, and desizing applications in the processing of textiles.

Rohm & Haas also pioneered in synthetic insecticides. For many years insecticides and fungicides were obtained either from botanical products such as nicotine, pyrethrum, or rotenone, or from inorganic chemical poisons such as the arsenates or copper compounds. The search for a satisfactory synthetic insecticide involved the preparation and testing of thousands of compounds before one that met the requirements completely was finally found in the thiocyanate family. Lethane, as the material was called, was introduced in 1926 and the market which developed gave ample evidence of its need. During the next two decades, Lethane came into use in most of the civilized countries of the world as the active ingredient for household, industrial, or agricultural insecticides. Later research brought additional products to the market, broadening the Company's activities to include fungicides, disinfectants, and sanitizing agents. Dithane, an agricultural fungicide, Rhothane, a high-powered insecticide of the DDT type, and Hyamine, a quaternary ammonium disinfectant, are outstanding products of this later research.

Another important development of the Rohm & Haas Co. goes back again to the early work of Dr. Röhm. In 1901 Dr. Röhm received his doctorate from the University of Tübingen. His thesis was based on acrylic acid esters, which he found polymerized to colorless substances that varied in physical properties from hard glasslike materials to soft rubbery ones. From this discovery came a spectacular new type of plastic—methyl methacrylate—which is marketed today under the Rohm & Haas trade-mark, Plexiglas. The initial investigation lay dormant for nearly 20 years while Dr. Röhm's time was absorbed elsewhere. But in the 1920's the study of the acrylics was revised and the problem was eventually taken up in the Bristol laboratory of Rohm & Haas. The many difficulties encountered in developing a commercial process for making sheet Plexiglas were finally solved and the crystal-clear plastic appeared on the market late in 1935. Its unique combination of lasting clarity, real weather resistance, nearly perfect optical properties,

and ready formability opened many new fields of use for plastics, the most important large-scale application being the making of formed enclosures for aircraft. During World War II Plexiglas was a vital war material, used on every type of Army and Navy plane. It has continued to be a standard material for aircraft since the close of the war, but it is in no sense limited to aviation. Facilities for manufacturing Plexiglas have been expanded to include acquisition of a plant at Knoxville, along with greatly enlarged capacity at Bristol. A plant for making various chemical intermediates is now being erected near the important "chemical capital" of Houston, Tex., and is scheduled to begin operations in 1948.

Increased facilities for the manufacture of plastics is only a part of the Company's expansion. In 1920 Rohm & Haas purchased the century-old Charles Lennig & Co. of Philadelphia. The name was retained and Lennig became an associate firm, supplying Rohm & Haas with many raw materials for its diverse lines of chemicals, and the chemical trade at large with the high-quality heavy chemicals for which it had long been well known. In 1926 expansion took another form with the organization of Resinous Products & Chemical Co., to manufacture and sell many kinds of synthetic resins. Ground adjoining the Lennig plant was acquired for this associate firm, and today the manufacturing operations of both Lennig and Resinous Products are located on this site in Philadelphia's industrially historic Bridesburg.

The research laboratory provided at Rohm & Haas' original Bristol plant underwent a series of expansions through the years. Twelve years ago it was decided to provide more adequate laboratory facilities for the entire group of companies by erecting a central research laboratory at Bridesburg. Plans were drawn to provide for the need then recognized and to allow for future expansion. Three stages of the proposed expansion have already been completed. In addition to the laboratory center at Bridesburg, two special laboratories are maintained at Bristol —one for the study of insecticides and related problems, and the other, a physics laboratory for investigation of the physical characteristics of various products, especially plastics.

Sales and distribution of the Company's products center in the main office located on Washington Sq. in downtown Philadelphia. In addition, branch sales offices have been established in key cities throughout the country, and an export department handles distribution of the Company's products in foreign countries. It has only been 40 years since Oropon was first introduced to the leather tanners of this country, but in these four decades the Company has grown from a small "one-product" concern operating in rented quarters, to a thriving association of three companies, with plants engaged in manufacturing scores of chemical products known around the world.

RUMFORD CHEMICAL WORKS may have the silhouette of Count Rumford incorporated in many of its trade-marks and its name indirectly linked with Benjamin Thompson, Count Rumford, but its beginnings were in Baron Liebig's laboratory in Giessen, Germany. In 1844 Eben N. Horsford, a graduate of Rensselaer Polytechnic Institute, and for four years professor of mathematics and natural sciences in the Albany Female Academy, was urged by Professor Webster of Harvard to study chemistry abroad. In December Horsford left for Giessen, where Liebig had recently introduced the practical teaching of chemistry in the laboratory. Here Horsford spent two years in the society of such men as Hofmann, Fresenius, Will, and many others who afterwards became famous. A great favorite of Liebig's, he was urged to take his Ph.D., but this he refused to do because he was living on borrowed money. Horsford returned to America

without a degree, but with his chemical knowledge well advanced, and bearing a paper he had written on glycocoll and a strong recommendation from Liebig. These caused his election, at the instance of Professor Webster, to the then-vacant "Rumford Professorship of the Application of Science to the Useful Arts" at Harvard, where he organized the laboratory of the newly founded Lawrence Scientific School after the Giessen plan.

Late in 1854 Professor Horsford, who had just obtained his first chemical patent, that of neutralizing chlorine in bleached cotton and linen fabrics by calcium sulfite, was asked to become a consultant to George F. Wilson & Co., of Providence, suppliers of chemicals to the local textile industry. Early that year George F. Wilson, a schoolteacher with a flair for salesmanship and a desire to enter business, had left the principalship of Chicago Academy and established his own chemical merchandising business. Perhaps Wilson found it difficult to secure agencies and supplies, for there were already four other chemical supply houses in Providence. At any rate, he sought Horsford's cooperation in the manufacture of chemical products. As Horsford was working on other ideas which he suspected had commercial value, association with Wilson promised to bring financial returns for his inventions.

A start was made in the manufacturing venture with a small calcium sulfite plant built at Pleasant Valley, R. I. Other chemical manufacturers were now more willing to entrust their sales to Wilson's company, with the result that its line was substantially expanded. Pleasant Valley was not a good site for chemical expansion, near-by neighbors complaining about the sulfur dioxide fumes, so in 1856 Wilson moved the equipment to a small site at East Seekonk. With this move the relation between Horsford and Wilson became an informal partnership.

At this time Horsford was working on an idea which went directly back to Giessen, when Liebig was developing his theories of the need for supplying growing crops with fixed nitrogen and phosphates, and expounding his idea that "no seed suitable to become food for man and animals can be formed in any plant without the presence and cooperation of phosphates."

Prior to 1850 the leavening of baked goods depended on yeast or sour milk and soda. Around 1850 the New England housewife began keeping on her pantry shelf separate containers of cream of tartar and "saleratus" or bicarbonate of soda as leavening agents. Then all the cream of tartar was imported from Italy whose war with Austria made supplies and prices erratic. Liebig's constant emphasis on the need for supplying phosphates to growing crops had suggested to Horsford the desirability of returning phosphates to milled flour to replace the phosphates lost in milling. He conceived the idea of developing an acid salt of phosphoric acid which would not only be a substitute for cream of tartar, but would also restore phosphates.

Shortly after the Wilson operations were transferred to East Seekonk, a process was developed for making a crude monocalcium phosphate and Horsford obtained a patent for a "pulverulent phosphoric acid" which would produce carbon dioxide from a mixture with carbonates. In 1856 phosphoric acid had not been produced on a commercial scale, so Horsford and Wilson had to pioneer a manufacturing process based on the raw materials available—bones or spent bone black from sugar-refining operations. Domestic phosphate deposits had not begun to be exploited, the first production coming from South Carolina in 1869, with the first working of the Florida hard rock and pebble phosphates beginning in 1889. The difficulties encountered by the partners were many, but within three years, production of monocalcium phosphate was on a satisfactory basis.

Rumford Chemical Works was incorporated in Massachusetts, May 13, 1859,

with $10,000 paid-in capital. Choice of the corporate name was Horsford's, in recognition of Benjamin Thompson, Count Rumford, as well as the Rumford Chair at Harvard University, which had been founded by a monetary grant under Count Rumford's will and which was occupied by Horsford from 1847 to 1863. Readjustment of the boundary line between Massachusetts and Rhode Island in 1861 having resulted in East Seekonk, Mass., becoming a part of East Providence, the Corporation changed its registration to Rhode Island. In 1865 Horsford and Wilson acquired the inactive Miantonomi Manufacturing Co., chartered in 1854 in Rhode Island, with $500,000 capital. Its charter was amended to provide for the manufacture of drugs and chemicals, and the name changed to Rumford Chemical Works in 1865. Later that year a bill of sale and deed was recorded covering the sale of Rumford Chemical Works of Massachusetts to Rumford Chemical Works of Rhode Island.

The business by this time had expanded to include manufacture of hydrochloric and nitric acids, and tin chloride. In 1864 Horsford patented a self-rising flour containing monocalcium phosphate and bicarbonate of soda in the equivalents used today. This patent also described a phosphate-type baking powder to be sold in a container holding separate packages of monocalcium phosphate and bicarbonate of soda. This product sold as Horsford's Bread Preparation and more than 80 years later it still sells in the South.

Horsford spent most of his time at Harvard, with regular visits to the Rumford plant where he maintained a small laboratory. Wilson continued to direct the manufacturing operations and sales, patenting various equipment for Horsford's processes. Thus, in 1868, patents were issued to him for a phosphoric acid pump with vulcanized rubber valves, and another for porcelain-lined iron kettles for concentrating phosphoric acid. About the same time Wilson became interested in manufacturing agricultural fertilizers from bone or spent bone black by double decomposition with molten sodium bisulfate. Stannous chloride, or tin crystals, was an important Rumford product in the 1860's and early 1870's. The equipment was manufactured by the Bennington Pottery, some of whose ware now occupies a prominent place in the Rumford Museum collection of early chemical equipment.

The original plantsite had been extended by purchase of adjacent land and by 1870 the Company owned 800 acres. An idea had grown in the mind of Wilson about the desirability of combining farming operations with the seasonal chemical business. In 1872 Rumford Chemical Works had 325 acres of land under cultivation for crops, 175 acres in pasturage, and 300 acres in woodlands awaiting clearance. It made its own butter and cheese, slaughtered its own cattle, and nearly all the produce was sold to employees. Thus Rumford practiced more than 70 years ago some of the ideas Henry Ford introduced 50 years later when he established small plants in Michigan and operated them in conjunction with farming enterprises.

Meanwhile Horsford, who had resigned from Harvard in 1863 but continued to live and experiment in Cambridge, where he had built a private laboratory in connection with his house, continued to center his attention on foodstuff uses of monocalcium phosphate. A ready-mixed leavening agent appeared in 1864, under the trade name, Horsford's Yeast Powder, packaged in bottles. Horsford experimented with various methods of increasing the stability of the mixture so it could be packed in metal cans. He discovered that dry starch would serve, so in 1869 Rumford began manufacturing baking powder as we know it today. This eventually became the principal product of the Company. Less and less emphasis was placed on manufacture of chemicals, and production of superphosphate and sulfate of ammonia fertilizer at the Riverside Works was abandoned.

As of 1870, the assets of the Company, then headed by Horsford, were valued at a little over $300,000, and by 1875 had increased to $500,000, without the introduction of capital other than $10,000 paid in 1859. This growth was recorded during a period of general business depression. The Company did not begin to pay dividends until 1878.

In 1873 Horsford engaged 24-year-old Charles A. Catlin, newly graduated with a B.S. and Ph.B. from the University of Vermont, as control chemist. In 1878 Catlin was appoined chief chemist, a position he occupied until his death in 1916. Catlin's 43 years with Rumford were devoted to investigations of dietary phosphates. The drying oven he constructed with Wilson in 1879 even today seems quite modern. Its successful operation contributed substantially to the stability of monocalcium phosphate baking powders. Catlin also devised a granular type of monocalcium phosphate which in 1890 became the standard of the Company. Horsford's patented baking powders and pulverulent phosphatic material were the subjects of infringement suits in the 1880's. Catlin's patent was similarly infringed and Rumford *vs.* New York Baking Powder, which ended in favor of Rumford, has often been quoted in texts relating to patent infringements.

With Wilson's death in 1883, executive control was transferred to Newton D. Arnold, aided by Cornelius S. Sweetland, both associated with the Company for several years. Horsford continued as president, but from 1883 to his death in Cambridge in 1893, his appearances within the plant were infrequent. In 1913 Sweetland was elected president, the first Rumford head who was neither a founder nor member of a founder family. In 1913 he appointed Dr. Augustus H. Fiske, grandson of Horsford, chief chemist and Ellery L. Wilson, a grandson of George F. Wilson, plant superintendent.

In the late 1920's the Company decided to return to an earlier pattern of manufacturing both baking powders and chemicals. In 1919 a Dorr-type wet process phosphoric acid plant was completed, using phosphate rock and purchased sulfuric acid. A contact sulfuric acid plant was erected in 1930 to take care of the needs of this unit and provide a surplus for local sales. The Rumford laboratory, under Fiske's direction, continued to investigate phosphates. Discovery of the useful properties of sodium tetraphosphate by Fiske and Charles S. Bryan (now chief chemist of Rumford) led to the construction of an experimental furnace in 1936. A commercial unit was built in 1938 and several substantial additions have since been made, sodium tetraphosphate now being one of the important products of the Chemical Division.

The retirement of Dr. Fiske in 1938, and the sudden death of Ellery L. Wilson that May, made necessary the selection of new executives. In December, Albert E. Marshall, consulting chemical engineer and Company stockholder (1931) and director (1936), was elected president. Under his direction chemical manufacturing was further expanded and new items added to the Grocery Products Division.

Up to 1938 Rumford Chemical Works had not undertaken organized research. Professor Horsford had performed experiments in his private laboratory, while Drs. Catlin and Fiske did theirs in the control laboratories. Construction of a separate research laboratory complete with pilot plant was therefore begun in 1940 and finished in 1941. Part of the facilities was used for a special development project of the Office of Scientific Research & Development, 1942-45, but with the end of the war, enlargement of the staff (now 16) and facilities was undertaken, under the supervision of Dr. Raymond L. Copson, research director since early 1946.

Rumford research falls into three divisions: (1), phosphate chemistry on which two researchers are engaged; (2) new products for the Chemical Division; and

(3) new products for the Grocery Division. The last are not necessarily foodstuffs, as is evident from the laboratory's successful development of the phosphate-base household detergent Noctil. A small market study organization, integrating its work between executive management and research laboratory, has been set up. A substantial amount of work is done on customers' problems, and the research personnel is also in active contact with production and chemical problems within the plant.

The original Company issue of 100 shares of $100 par value had, by 1922, been increased to 6,800 shares. On Dec. 15, 1922, a 100% stock dividend increased the number of shares to 13,600 at $100, and at the same time $500,000 preferred stock, which was called in 1940, was sold to finance purchase of Layton Pure Foods of St. Louis, manufacturers of baking powders. This plant was operated for 15 years, then its equipment, sales offices, etc., were moved to Rumford, where a new five-story baking powder plant had been built in 1929. After the preferred stock had been retired, the authorized capital was changed to $2,000,000, divided into 100,000 shares of $20 par value, and a five-for-one split converted the outstanding stock to 68,000 shares of $20 par value. Late in 1945 the issued stock was increased to 81,500 shares by the sale of 13,500 shares.

Rumford's presidents, with their years in office, have been: George F. Wilson, 1854-67, 1877-78; Eben N. Horsford, 1867-77, 1878-93; L. H. Farlow, 1893-1913; Cornelius S. Sweetland, 1913-23; Andrew Fiske, 1923-30; Gardiner H. Fiske, 1930-38; Albert E. Marshall, 1938-present.

SANDOZ CHEMICAL WORKS, INC., in the past six decades has grown from a small factory in Basel, Switzerland, to a large organization with representation and manufacturing plants throughout the world. In 1886 two pioneer Swiss chemists, Kern and Edward Sandoz formed a partnership, "Sandoz," for the synthesis of coal-tar dyes. They marketed these dyes in the United States through well-known wholesalers, but in 1919 decided upon setting up an American selling organization in direct contact with the ultimate consumer. Ernest Gossweiler organized the American branch, a New York corporation named Sandoz Chemical Works, Inc. He is now its president, while James C. Walker is vice-president and technical director, and Dr. Emil Rothenberger, vice-president and manager of the Pharmaceutical Department. From its one sales office in New York and agents in other cities, Sandoz has grown to include sales offices in Boston, Philadelphia, Charlotte, N. C., Los Angeles, Chicago, Paterson, and Providence.

After World War I the Swiss, seeing that the United States was determined to build its own dyestuff industry, in 1920 helped establish the Cincinnati Chemical Works in Norwood, O. Products manufactured by this concern, augmented by importations from Switzerland, have enabled Sandoz to supply the American consumer with high-quality dyes.

In addition to its regular range of colors for cotton, silk, and artificial fibers, Sandoz manufactures specialties for wools and worsteds. In 1908 Sandoz chemists discovered xylene light yellow 2G, the first fast-to-light and level-dyeing acid yellow to be manufactured. It set the standard for the broad range of Sandoz quality colors to come, including Alizarine Light colors, a level-dyeing group of acid colors, and the Brilliant Alizarine Milling range, a fast-to-light and milling acid group. The one-bath, metachrome method of dyeing, long handicapped by lack of suitable fast colors, has been advanced by the Company's development of Metomega Chrome colors.

As an adjunct to the dyestuff business, Sandoz manufactures in its plant at Fairlawn, N. J., a complete line of textile and leather finishes, water repellents,

and other aids to textile processing. New construction is under way to enlarge the present facilities.

Heading the Pharmaceutical Division is Dr. Arthur Stoll, an authority in biochemistry and enzymes. Application of new and delicate biochemical methods developed during years of extensive study on chlorophyll, a problem closely related to native plant chemistry, has met with unusual success. The remarkable progress in the chemistry of such drugs as ergot, digitalis, senna, etc., is closely linked with the scientific research done in the Sandoz Research Laboratories. Here all Sandoz pharmaceutical specialties have been developed. These are limited to a comparatively small number of preparations of recognized value, a high percentage of which has been approved by the Council on Pharmacy & Chemistry of the American Medical Association.

More than 100 years ago, an American physician discovered the therapeutic properties of ergot. A crude extract was used to stop excessive bleeding during childbirth, but many obstetricians feared to use it because of the painfulness of the injections and the frequency of serious side-effects. In 1918 Dr. Stoll isolated pure ergotamine, the active principle of ergot. Extensive pharmacological and clinical study of the new drug led to its use as a specific against migraine. Later, Dr. Rothlin, director of the Sandoz Institute for Pharmacology & Medical Research, prepared some new hydrogenated derivatives of ergot alkaloids less toxic than pure ergotamine. The result was D.H.E. 45, recently introduced on the American market after many years' clinical evaluation in the foremost American medical colleges.

Similar important discoveries were made in the field of digitalis with the introduction by Sandoz of a series of pure active principles under the names of Cedilanid, Digilanid, Strophosid, and Scillaren. The latest Sandoz drug to be marketed is Mesantoin, for the treatment of epilepsy, which has been tested clinically for the past five years. In Glysennid, Sandoz introduced a laxative composed of the two pure laxative principles of senna, which has proven to be free from side-effects. Sandoz' calcium gluconate is the only calcium preparation which can be injected intramuscularly without causing gangrene and scars.

With many problems in medicine still unsolved, the Sandoz Research Laboratories are forging ahead in continued research by well-selected teams of physicians, chemists, pharmacologists, and bacteriologists.

R. P. SCHERER CORPORATION, which was originally known as Gelatin Products Co., was founded by Robert P. Scherer in Detroit, Feb. 1933, a century after the French pharmacist, Mothes, first invented a gelatin capsule. Utilizing the basement of his father's home, Scherer, fourth son of a practicing physician, and with three months' experience in a pharmaceutical house, developed a machine which filled and sealed soluble elastic capsules, tubes, and enclosures in one operation. A patent issued Aug. 13, 1934, covers Scherer's invention which employs the rotating die principle and is therefore a radical departure from the French plate method.

With loans from his family, Scherer and four employees began manufacturing and marketing filled soluble elastic gelatin capsules to pharmaceutical and drug manufacturers, in a small store on Gratiot Ave. An expanding market necessitated a move to bigger quarters. In 1935 operations were removed to a factory on Hancock Ave., where with 30 employees the Company enlarged its production facilities, control and research laboratories, and machine shop. On June 30, 1937, Gelatin Products changed to a Michigan partnership by the admission of Scherer's wife and

three of their children into the business. Another son became a partner two years later.

In 1937 ten acres were acquired on Grinnel Ave. for a modern pharmaceutical plant which was completed late in 1939. This plant enabled the Company to increase production and enlarge research, control, and engineering facilities. A Fine Chemicals Division was also established to research and manufacture products used in the Company's manufactured capsules and for bulk sales to the pharmaceutical trade. Four new buildings were added in 1941 and further expansions were made in 1943-44, affording, in all, approximately 150,000 sq. ft. for approximately 800 employees. In 1933, prior to the rotary die process machine, the total annual gelatin capsule production reached approximately 300 millions; since then as high as 5 billions by R. P. Scherer Corp. alone.

The Company's earliest operations were largely confined to encapsulation of materials furnished by customers, such as fish liver oils, some medicaments, and later vitamins. Afterwards the enterprise manufactured the contents of its capsule, tube, and enclosure production, in most cases. Today the Fine Chemicals Division manufactures vitamin D (Steenbock process), calcium pantothenate, amino acids, lactalbumin, niacinamide, etc. The Corporation also makes capsules, tubes, and enclosures for vitamins, medicinals, veterinary products, foods, adhesives, cigarettes, lighter fluids, golf ball centers, cosmetics, flavors, and other industrial uses.

A control laboratory maintains control by assays, tests, and analyses of all raw materials and finished products. The Research Laboratories have conducted extensive research programs and have developed methods of capsulating various materials, particularly vitamins and solids. The Company owns 36 U. S. Patents, in addition to the basic machine patents, covering devices and processes relating to capsule and chemical manufacturing. It participates in researches conducted by various colleges and universities, and has made grants to the Hillman Clinic of the University of Cincinnati and the National Vitamin Foundation for cooperative projects.

All sales are to manufacturers, the largest customers being drug and pharmaceutical houses. A branch sales office was opened in N.Y. City in 1941 and has maintained close affiliation with Gelatin Products, Ltd., of Canada, in Windsor, Ontario, and Gelatin Products, Ltd., of England, in Slough, Buckinghamshire, whose stocks are owned by Robert P. Scherer.

Incorporation as Gelatin Products Corp. occurred in Michigan on May, 26, 1944, with Robert P. Scherer, president; Edward W. Johnson, secretary-treasurer; and these officers plus Margaret L. Scherer and Paul Marco, directors. The name was changed Aug. 1, 1947 to R. P. Scherer Corp., with no change in management or ownership.

SCHOLLER BROTHERS, INC., was founded by Adolph, Henry H., and Fred C. Scholler, Dec. 24, 1907; capital, $2,000; purpose, to manufacture soap, softeners, and sulfonated oils for textiles. The Company was incorporated on June 10, 1914, capital $15,000, with Fred C. Scholler, president; Adolph Scholler, vice-president; and Henry H. Scholler, secretary-treasurer. From the beginning the Company has had a consistent growth. In 1930 the capital was increased to $250,000. Scholler Bros., Ltd., St. Catharine's, Ont., a subsidiary, was incorporated in 1927, with capitalization of $50,000. Trisco Products, Inc., a selling organization, was incorporated in 1936. Present capital and surplus of the parent company is now over $1,000,000, and of the Canadian subsidiary, $300,000.

Scholler Bros.' plant consists of two buildings, totaling 200,000 sq. ft., and

employing 68 persons. During the years, the Company added new products and today manufactures a complete line of textile soaps, sulfonated oils, softeners, wetting agents, degumming compounds, scouring agents, penetrants, and finishes for all fibers. It has contributed considerably to scientific advances in the dyeing and finishing of textiles, particularly hosiery. It pioneered the one-bath method of boiling-off and dyeing silk hosiery and developed nonlathering boil-off oils for this purpose. These oils are sold under the trade name of Tri-A-Nol. Another accomplishment is the development of combination, dull, repellent finishes for all fibers, which are widely used on silk, rayon, and nylon hosiery, and sell under the trade name of DuraBeau finishes.

Henry H. Scholler died in 1936 and Adolph Scholler, in 1939. The present officers are Fred C. Scholler, president· L. O. Koons, vice-president and treasurer; I. M. Buch, secretary; and L. A. Scholler, assistant secretary. The Company also sells under the trade names: Creamoyl, Trisulphoil, Kier-Wite, Brosco, Trisco, and 8T8.

G. D. SEARLE & CO. was founded back in 1888 by Gideon D. Searle in Omaha, Nebr. The firm's first catalog, published Jan. 15, 1889, listed some 400 standard fluidextracts, 150 medicinal elixirs, 100 medical sirups, 30 medicinal wines, 75 standard powdered extracts, 25 standard tinctures, 150 standard group botanic drugs, and a handful of such specialties as compound digestive powder and the aromatic sirup yerba santa. The following year the firm moved to Chicago and its catalog and price list, dated Mar. 1, 1891, carried, in addition to the long list of original preparations, such new specialties as Quinimel "for disguising the bitterness of quinine" and Kali-Caffeine, "a delightful effervescent drink, excellent in refreshing qualities and palatability."

By 1892 the Company offered one of the first lines of compressed tablets to become available to the American physician. Several hundred compressed and hypodermic tablets and tablet triturates, as well as compressed lozenges, were added to the 1892 catalog, bringing the total number of Searle products above the 1,000 mark. These developments were prophetic of the course to follow. G. D. Searle & Co. has always served the medical profession. From the beginning it has manufactured only ethical pharmaceuticals. It has consistently pioneered in research on new specialties and has promptly adopted new and improved research methods and manufacturing processes.

The business grew and in 1909 Dr. Claude H. Searle, who following his graduation from Rush Medical College practiced medicine, joined his father and became vice-president. In 1917 Dr. Searle succeeded his father as president and remained the active head of the business until 1936, when he, in turn, was succeeded by his son, John G. Searle. Dr. Searle continued as chairman of the board until his death on Oct. 22, 1944.

In the early 1920's, G. D. Searle & Co. offered the medical profession a line of arsenicals prepared under an improved process, culmination of original research by Kober, a recognized authority in this field. Following the preliminary work on arsenicals done in Germany by Ehrlich, the Searle arsenicals were for a number of years among the few such products obtainable on the American market. In 1930 the Searle research laboratories developed aminophyllin, the pioneer American brand of theophylline ethylenediamine, revolutionizing the treatment of certain respiratory and cardiac disorders. Searle developed other dosage forms and combinations of aminophyllin, including tablets, ampuled solutions for injection, combinations with phenobarbital and potassium iodide, and suppositories. Shortly after the introduction of the arsenicals arsphenamine, neoarsphenamine, and sulf-

arsphenamine for the treatment of syphilis, the Company added bismuth sodium tartrate for adjunctive treatment.

When John G. Searle joined the Company as treasurer in 1923, shortly after his graduation from the University of Michigan, the firm had just moved from Ohio and Wells Sts. into new quarters in the Ravenswood section of Chicago's North Side. In 1925 its constantly expanding business demanded still larger quarters, so a building was purchased at the corner of Lawrence and Ravenswood Ave., which was its home for the following 17 years.

The Company was now so firmly established in pharmaceutical specialties that its research facilities were vastly expanded. One of the first research projects was in amebiasis, studies which were intensified by the epidemic of amebic dysentery at the Chicago World's Fair in 1933. These studies led to the development of Diodoquin (5,7-diiodo-8-hydroxyquinoline), a potent amebicide which has since become standard treatment. Diodoquin was widely used during World War II, helping to control amebic dysentery which has plagued armies throughout history. Searle research during the early 1930's also pioneered in development of keto-cholanic acid therapy. By combining the oxidized or keto form of all four bile acids normally present in human bile—cholic, desoxycholic, chenodesoxycholic, and lithocholic—it developed Ketochol which, due to the oxidation of these hydroxy-cholanic acids, is relatively nontoxic.

Antispasmodics research resulted in the synthesis of Pavatrine (β-diethylamino-ethyl fluorene-9-carboxylate hydrochloride) which was offered the medical profession in 1943. A potent non-narcotic spasmolytic in dysmenorrhea, gastrointestinal spasm, and urinary bladder spasm, its usefulness was further broadened (1944) by combining with phenobarbital. Other Searle products perfected in recent years are Tetrathione for peripheral vascular diseases; Gonadophysin, a gonadotropic anterior pituitary hormone; Sylnasol, a new sclerosing agent for varicose veins, rhinitis, and bursitis; Metamucil, an extract of the psyllium, *Plantago ovata,* seeds combined with dextrose, which became the first hydrophyllic mucilloid accepted by the Council on Pharmacy & Chemistry of the American Medical Association; Iodochlorol, an iodized oil for both contrast roentgenography and treatment; and Floraquin, a combination of Diodoquin, lactose, dextrose, and boric acid for the treatment of vaginitis. The latest research development has been Hydryllin, a new antihistaminic combining diphenhydramine with aminophyllin, which has been found effective in certain allergies.

The success of these and other Searle specialties taxed the Company's production and distribution facilities till it was compelled to discontinue most of the older products, reducing the line from over 1,000 different items to less than 25.

Becoming vice-president and general manager in 1931 and president in 1936, John G. Searle began planning 10 years ago for a pharmaceutical research and production plant which would be the latest, best-equipped, and most functional in the industry. He began searching then for a location away from the dirt, noise, and congestion of industrial centers, yet convenient to adequate transportation facilities. Ideally it should be situated in a small, homelike community. Such a location was found on Searle Parkway in Skokie. A five-acre tract was purchased, and construction begun June 1941. Mar. 9, 1942, the Company moved into its new quarters whose three stories and English-type basement provide 123,000 sq. ft. of floor space—1,300,000 cu. ft.—for all the Company's varied research, manufacturing, and recreational activities. The laboratories themselves occupy less than half the area, the remainder being appropriately landscaped. In addition, early in 1944 five and one-half acres across Searle Parkway were acquired and con-

verted into the beautifully landscaped new Searle Park, which provides all sorts of recreational conveniences for Searle personnel.

By 1945 the Company's research and production needs were outgrown, so in the spring of 1946 ground was broken for four additional structures to be built on the newly opened nine and one-third-acre tract south of the Searle Laboratories. The new group consisted of a Biology Bldg. to house all research units doing animal work, including pharmacology, physiology, endocrinology, and bacteriology, and all animal quarters; Chemical Manufacturing Bldg. with a ground area one-third as large as the present laboratories; a 150x240 ft. warehouse; and power plant.

Hardly had these building operations been started before further facilities were demanded. Accordingly, work was begun on two more structures—a new 100x225 ft. Pharmaceutical Bldg. for the granulating, tableting, coating, and liquid departments, and an additional wing for the Biology Bldg. which will more than double its capacity and provide facilities for organic chemical as well as biologic research, these combined structures being known as the Research Bldg.

SEMET-SOLVAY COMPANY (now Semet-Solvay Division, Allied Chemical & Dye Corp.) was organized July 8, 1895, to engage in the construction and operation of by-product coke-oven plants. Several years of successful operation of the first by-product coke plant in this country at Syracuse, N. Y., by the Solvay Process Co. showed that the potentialities warranted formation of a company to engage exclusively in the industry.

In 1896 Semet completed construction of a by-product coke-oven plant consisting of 50 ovens for Dunbar Furnace Co. (subsequently American Manganese Co.), at Dunbar, Pa. Prior to that time many furnace men felt that by-product coke would be unsuitable for blast-furnace use because it was not as large as beehive coke and did not have the latter's carbon glaze. Operations with coke produced at the Dunbar plant under management of Semet-Solvay proved these fears unfounded and by 1904 it had been expanded to 110 ovens. This was the first acceptance by the blast-furnace industry of by-product coke.

Following this success, by-product coke-oven plants were constructed in rapid sequence throughout the country for steel and other industrial users, as well as for Semet itself and for Solvay Process. By the end of 1916, a period of 21 years, Semet-Solvay had erected approximately 1,800 by-product coke ovens in the United States. In addition it has been a leader in plant operation. The Company operated many of the plants which it constructed for others as well as its own plants. Experience thus gained has not only resulted in improvement in operating technique, refinement of product, and development of new products, but in the up-to-date design and improvements in coke ovens constructed by Semet-Solvay.

The original Syracuse plant was the first in the country to produce concentrated sulfur-free ammonia liquor without introduction of chemicals. In 1899 a process was developed for removal of high-boiling sulfur-bearing residue from acid-washed light oil. When left in the oil the residue decomposed during subsequent distillations, causing contamination of products and equipment corrosion.

Semet-Solvay Co. was also the first operator in the United States to produce pure grades of benzene, toluene, and solvent naphtha. In 1900 it erected at Syracuse a plant to produce benzene and toluene from crude light oils recovered from coke-oven gas. This plant was also an untried venture for at that time there was practically no demand for these refined products in America, and Semet pioneered in developing a market for them. A benzene plant is a natural adjunct to a by-product coke-oven plant, but Semet has found it advisable to enlarge its light-oil

refining facilities at Syracuse, shipping here all crude light oils produced at its other plants or purchased from other operators. Also in 1900 Semet began the commercial production of synthetic phenol, which was converted into trinitrophenol (picric acid) and this ammoniated to ammonium picrate. Manufacture of picric acid for the U. S. Government was first undertaken by Semet at this time.

During the next 10-15 years, the Company devoted much effort to improving operations in this infant industry and experimenting to improve product, develop new products, and further eliminate waste. At various plants, Semet intalled and operated equipment for the manufacture of ammonium sulfate, for recovery of cyanides, for manufacture of briquettes from coke breeze, for production of pyridine, Crysolite paint, and other products. In addition, it experimented with further uses and refinements of coal-tar oils, use of silica brick for coke-oven linings, use of tar as fuel, use of benzene in gas engines, manufacture of ethylene, as well as other subjects of experimentation and development.

In 1910 the Benzol Products Co. was organized jointly by Semet, General Chemical Co., and the Barrett Co., to manufacture aniline oil and aniline salt at Frankford, Pa. In the same year, equipment was installed at Syracuse for manufacture of ammonium chloride. Two years later, a Department of Special Products was formed, in conjunction with Solvay Process, for utilization of waste products.

Semet-Solvay's research and experimentation in the fields of coke-oven by-products proved of substantial benefit to the World War I effort. In 1914 Semet built at Split Rock, N. Y., a plant to manufacture nonsensitive explosives, picric acid, ammonium picrate, and trinitrotoluene. From this plant, which was greatly expanded during the war years, and a similar unit at Syracuse, Semet supplied the U. S. Army and the Allies with large quantities of these munitions. It also played a leading role in the development of products to replace coal-tar chemicals formerly imported from Germany. In 1915 the Company constructed at Marcus Hook, Pa., for the Benzol Products Co., a plant to produce aniline and other intermediates. At the same time, Semet erected plants at Steelton, Pa., and Ashland, Ky., for the manufacture of yellow prussiate of soda (used in making paint pigments and dry colors). It also erected at Syracuse, N. Y., a new benzene plant to replace the plant constructed in 1900, and facilities for conversion of phenol into salicylic acid and sodium salicylate.

In 1916 Semet-Solvay Co. installed equipment for the manufacture of chrome black, sodium bisulfite, and red prussiate of soda, for the recovery of sodium sulfate from carbolic acid, and for the recovery of naphthalene. Next year, the Company designed and constructed ammonia-recovery stills for use in connection with the ammonium carbonate leaching of copper, nickel, and titanium ores, and erected a chlorine plant at Syracuse. This year also, Semet sold its interest in Benzol Products Co. to National Aniline & Chemical Co.

Semet made a valuable contribution to the successful prosecution of the war by building at a rapid rate additional coke ovens and auxiliary equipment for the nation's steel and chemical industries. In addition, the Company operated its own by-product coke-oven plants during this period at utmost capacity. Some years prior to the war, the Company had acquired an interest in coal-mining properties in West Virginia and Kentucky and was thus in a position to keep its plant operations at maximum capacity despite the shortage of coal.

For about two decades following World War I, Semet-Solvay Co. concentrated upon its operations rather than upon the construction of coke ovens for others. However, it kept its construction organization together and did a certain amount of construction work, and in 1937 actively re-entered this business. In 1940 it

acquired the Wilputte Coke Oven Corp. which had been actively designing and constructing coke-oven plants throughout the world since 1914. Since 1940, Semet's coke-oven construction activities have been conducted entirely through the Wilputte Corp., now Wilputte Coke Oven Division of Allied Chemical & Dye Corp.

Between 1918-21, Semet erected for its own use electrolytic caustic potash and hydrochloric acid plants at Solvay, N. Y., and a plant for manufacture of methyl salicylate at Syracuse, and successfully developed a process for removal of high-boiling, benzene-free residue from crude light oil in the light-oil stripping plant.

In Jan. 1921, Semet-Solvay Co. became a subsidiary of Allied Chemical & Dye Corp., and in 1926 transferred to the Solvay Process Co. some of its facilities at Solvay, N. Y., for manufacturing ammonium bicarbonate, ammonium chloride, benzaldehyde, benzyl chloride, caustic soda, chlorine, monochlorobenzene, *p*-dichlorobenzene, muriatic acid, and sodium nitrite. During the 1920's and 1930's, Semet added to its coal-land holdings, in order to expand its supply and to replace exhausted mines. In 1941, to facilitate transportation of coal to Semet's plants at Ashland, Ky., and Ironton, O., on the Ohio River, Semet acquired marine equipment which it operates on the Kanawha and Ohio Rivers. To supply the growing domestic demand for coke, large coke distribution yards are maintained at Buffalo, Cincinnati, and Louisville.

In 1927 Semet-Solvay Co. formed a separate company, Semet-Solvay Engineering Corp., to handle most of its engineering work and to acquire Steere Engineering Co., organized in Michigan in 1914, which had actively engaged in design and construction of water-gas plants and coal-gas retorts. Steere, prior to its acquisition, had developed welded plate construction of water-gas machines and accessory equipment and was the first company to construct welded oxide purifiers in the field from mill plate and structural shapes.

Since its organization, Semet-Solvay Engineering Corp. has been primarily engaged in engineering, construction, and development work in connection with the chemical and gas-manufacturing industries. It has made many valuable contributions in these fields, as may readily be seen from the following brief summary of some of its activities:

1928—Designed and constructed largest blue-gas plant in the world up to that time.

1929—Sponsored backrun process of water-gas manufacture and developed the three-way valve essential to its satisfactory operation.

1930—Developed process for conversion of CO_2 to CO in gas generators.

1931—Developed Ignition Arch and Ignition Dome process for heavy oil carburetion of water gas.

1934—Developed process for cleaning and conditioning producer gas from bituminous coals, making it possible to distribute to small burners without usual interruption.

1935—Developed process for production of Special Producer Gas, free from hydrogen, oxygen, and sulfur, and also dry.

1936—Designed and erected first reverse flow water-gas machine using gas oil and heavy oil, the most outstanding improvement in carbureted water-gas manufacture in many years. Developed continuous process for de-emulsifying water-gas emulsions.

1937—Designed and erected light-oil refining plant (for Carnegie-Illinois Steel Corp., at Clairton, Pa.), largest in the world, operating on a continuous basis.

1939—Developed cone bottom washbox with bottom overflow, especially adapted for heavy oil carburetion.

1941—Developed process for recovery of ammonia from coke-oven gas and

the continuous production of large crystal ammonium sulfate with low differential pressures in recovery apparatus. Crystal size under exact control by use of Krystal process, American rights to which for by-product ammonium sulfate are controlled by Semet-Solvay Engineering Corp.

Semet-Solvay Engineering Corp. maintains a modern, well-equipped shop at Owosso, Mich., for the fabrication of the various machines and equipment required in its engineering work.

Prior to the United States entry into World War II, Semet had been refining toluene and benzene into grades suitable for nitrating into explosives and for other ordnance purposes, and had been expanding these facilities. Large quantities of light oil from other producers were shipped by U. S. Army Ordnance to Semet's Syracuse plant for refining into the desired nitration-grade products. The principal output of this plant consisted of nitration grades of toluene and benzene not one gallon of which was ever rejected for failure to meet the rigid specifications established by the Government. The Army-Navy "E" award was granted this plant in Nov. 1942, and subsequently four "stars" added.

In addition to Semet's output of war materials from its own by-product coke-oven plants and related facilities, Wilputte Coke Oven Corp. rendered services as engineers, designers, and erectors of by-product coke-oven plants, including by-product apparatus and light-oil refining facilities. During World War II it designed and built for others over 700 ovens. Normally the activities of Semet's other engineering subsidiary, Semet-Solvay Engineering Corp., are devoted primarily to the public utility and by-product coke-oven industries, but during World War II, a large part of its efforts was devoted to gas machinery and allied apparatus for the Army Ordnance Department and other government agencies. In addition, it undertook projects covering special problems. Engineering services and equipment were furnished to important chemical construction companies engaged in the war effort, as well as to the Chemical Warfare Service at Huntsville Arsenal, Ala., and the Holston Ordnance Works, Kingsport, Tenn.

SEYDEL CHEMICAL COMPANY was founded by Herman Seydel and his brother Paul, first as the Atlanta Compound Co. and later as the Seydel Manufacturing Co., manufacturers of textile chemicals.

Herman, who was born in Brussels, 1877, and educated in Belgium and Germany, was for a short time employed by Destree & Wiescher, operators of a small dyestuff factory in Haaren, Belgium, before coming to the United States in 1896, as color chemist for Kalle & Co., in N. Y. City. From 1899 to 1904 he was a salesman in the South for the Berlin Aniline Works of New York. The Atlanta Compound Co. which Herman and Paul organized in Atlanta, Ga., in 1904, pioneered service to the textile industries making warp dressings, cloth finishings, softeners, etc. Their trade-mark Sizol became known far and wide, exports going to Canada, South America, and even Europe and India. The plant and office were moved to Jersey City in 1909, when the business was incorporated as the Seydel Manufacturing Co.

During the First World War the Company manufactured fine organic chemicals for the Government. Beginning with nitrobenzene, it was among the first makers of *p*-phenylenediamine and similar dyes from aniline. A research laboratory was established and succeeded in making benzoic acid by direct oxidation of toluene with nitric acid. In 1920 the organization was further enlarged and its name changed to the Seydel Chemical Co. The scope of the business was extended in many directions to include the manufacture of benzoic acid and its derivatives, anesthetics, and other fine chemicals used mainly as bases for medicinal prepara-

tions. Seydel benzoates have now been serving the food, beverage, and drug industries for over a quarter of a century. This sustained service has led many to speak of Seydel as "The House of Benzoates."

In 1933 the Pharmaceutical Department was organized to promote the manufacture and application of products which had been studied for several years. The first of these was Mercodel, metallic mercury comminuted into C.P. glucose, for the treatment of diseases caused by spirochetes. The second was sodium benzyl succinate, a vasodilator and sedative now marketed as Mobenate. The next, Benacol, is widely known as the first anesthetic in oil. Its companion product, Pilonol, was launched ten years later.

In 1934 the Committee on Rheumatism presented to the medical and chemotherapeutic professions the challenge to attack the fort of rheumatism. In 1936 the Seydel Laboratory announced favorable results in rheumatoid conditions through the means of the calcium double salt of benzoic acid and succinic acid benzyl ester. This double salt, since trade-marked Subenon, is being dispensed throughout the nation. It has lately been studied in rheumatic fever and sustained research in these fields offers much promise of continued success. This was confirmed by the chief of the Arthritic Clinic, Jersey City Medical Center, who published a paper in 1937 under the title, "A Logical Treatment of Chronic Arthritis." Later on, Gubner and Szucs conducted a comparative study of 150 cases of rheumatic fever and under that title reported their findings in the *New England J. Med.*, Nov. 1945.

The Seydel Laboratory has continued its study of preventive medicine as the most promising field for the abatement of virus diseases. Today (1948), the benzoate production is being extended through the manufacture of benzoic and substituted benzoic compounds, the demand for which is ever increasing from the pharmaceutical and allied fields.

The management of the Seydel Chemical Co. is in the hands of Herman Seydel, president, and Charles H. Seydel, secretary-treasurer. The Cloroben Corp., organized in 1936 to manufacture Cloroben products especially developed for the field of sanitation, has as its officers: Herman Seydel, president; Harold B. Seydel, vice-president; and Charles H. Seydel, secretary-treasurer.

SHARP & DOHME began its existence in 1845 when Alpheus Phineas Sharp, the first graduate of the Maryland College of Pharmacy, opened an apothecary shop in Baltimore. At first, he was more merchant than pharmacist. But he also sold such household remedies of the day as senna and manna, black draught, Benson's plasters, Seidlitz powders, antibilious pills, toothache drops, licorice, fennel, camomile tea for babies, soothing sirup, and tincture of arnica.

Six years later Sharp took on a 15-year-old German lad, Louis Dohme, as an apprentice. Dohme learned the business rapidly and in his spare time attended the Maryland College of Pharmacy, graduating in 1857 and becoming pharmacist in the store. He placed Sharp's prescription business on a call and order business and in 1860 became a partner of the firm whose name was changed to Sharp & Dohme.

The Civil War gave impetus to the young business which supplied medicines to the Union Armies. In 1865 Sharp & Dohme purchased the building next door to the apothecary shop, installed equipment, and began manufacturing medicines. Charles Dohme, a brother, headed production, while Louis undertook sales to physicians, pharmacists, and wholesale druggists. At first his travels were confined to near-by cities, but gradually they extended to the greater part of the

country east of the Rockies. The business prospered, the laboratories were enlarged, and branch offices were opened in New York and Chicago.

Sharp retired from the firm in 1885 and his interest was purchased by Louis and Charles Dohme. Sharp & Dohme was incorporated in 1892 with Louis Dohme, president; Charles Dohme, 1st vice-president; Dr. A. R. L. Dohme, Charles's son, 2d vice-president; Ernst Stauffen, secretary-treasurer and general manager. As business increased, branch offices were opened in Atlanta, New Orleans, St. Louis, Kansas City, San Francisco, Philadelphia, and Boston.

Two of the most successful Sharp & Dohme products at that time were Lapactic pills, a mild laxative, and soluble hypodermic tablets. The research laboratories were directed by Dr. Dohme. In 1903 Sharp & Dohme introduced one of its most widely known drugs, fluidextract cascara sagrada. This was followed by such prescription specialties as Pan-Peptic elixir, Benzothymol, Sal Laxa, Benzylets, Glycerophosphates Compound, Methylets, Saccharets, Sodium Phosphate Compound, Solmides, Luzo, Cresatin, in addition to all the standard U.S.P. and N.F. products.

In the 1920's, when interest in antiseptics was at its height, Sharp & Dohme laboratories synthesized a new series of resorcinols. Experimental and clinical studies indicated that hexylresorcinol was the most efficient germicide in this group. In cooperation with Dr. Veador Leonard, it was quickly made available to the medical profession as a nontoxic urinary antiseptic, trade-named Caprokol. It was also incorporated into other Sharp & Dohme products: S. T. 37 (antiseptic solution), Sucrets (antiseptic throat lozenges), and Crystoids (anthelmintic pills).

In 1929 the Company purchased the assets of H. K. Mulford Co. which was merged under the Sharp & Dohme name. Mulford had also originated as a drugstore, one of the oldest in Philadelphia. Under Milton Campbell, it opened biological laboratories at Glenolden, Pa., from which, in 1894, came the first diphtheria antitoxin to be produced in this country. Mulford laboratories were the first to supply smallpox vaccine commercially in the United States, as well as other important biological products. They also were the first to supply biologicals in piston syringes ready for administration. After the merger, the general offices of Sharp & Dohme were moved to Philadelphia, where the pharmaceutical laboratories, covering over 11 acres of floor space, are also housed. The biological and research laboratories are situated on an extensive 250-acre tract at Glenolden.

Reorganization of the two companies culminated in 1935 in the election of John S. Zinsser, a distinguished chemical engineer, as president. His election inaugurated great activity by the Company in new product research. During 1935-46, Sharp & Dohme research played a major role in developing five of the sulfonamides now in general use, the firm controlling by specific or generic patents four of the seven most effective compounds and sharing all rights to a fifth.

In 1939, under the leadership of Zinsser and Dr. William A. Feirer, vice-president in charge of medical research, Sharp & Dohme announced the synthesis of sulfathiazole. But patent application on the compound became involved in a Patent Office interference with similar claims filed by several other manufacturers. Also in 1939, Sharp & Dohme developed the first combination of sulfanilamide and the pyrimidine group: methylpyrimidinesulfonamide or sulfamerazine. After three years of extensive clinical study, it was released for use by physicians. Sulfamerazine has the same therapeutic effects as its close chemical relative, sulfadiazine (sulfapyrimidine), synthesized several months later by a different laboratory, but is active in about half the dose. Sharp & Dohme's priority in this synthesis has been recognized by a patent granting it control of all the 2-sulfapyrimidines, including sulfadiazine, sulfamerazine, and sulfamethazine (sulfadimethyl-

pyrimidine), a new highly soluble preparation with greatly reduced possibility of kidney damage. Two additional sulfonamides produced, which are of exceptional value in intestinal infections were Sulfasuxidine (succinylsulfathiazole), released in 1942, and Sulfathalidine (phthalylsulfathiazole), introduced in 1946. Sulfathalidine is therapeutically effective in half the dose of Sulfasuxidine.

In 1940 the Medical Research Division of Sharp & Dohme undertook an exhaustive study of the new antibiotic, tyrothricin, derived from a soil microorganism. In 1942 tyrothricin concentrate was released to doctors for local treatment of skin and certain other infections. Prothricin, the first nasal preparation to contain an antibiotic, was released by Sharp & Dohme in 1944. It combines tyrothricin with the vasoconstrictor Propadrine (phenylpropanolamine hydrochloride). A third product utilizing tyrothricin released by Sharp & Dohme the same year was Tyroderm, a water-washable ointment.

Sharp & Dohme research was also extended to the inherent perishability of biologic substances. Protracted investigation indicated that quick freezing, followed by vacuum sublimation from the frozen state would preserve biologic materials indefinitely. Sealing the container under vacuum gave an advantage, particularly in restoration. The desiccated substance could be quickly restored to its former state, without loss of potency, by the addition of sterile distilled water. Working in close collaboration with other scientists, Sharp & Dohme engineers designed and perfected the complex machinery for quick freezing and vacuum dehydration of biological materials. The process was called the lyophile technique and the products thus preserved, Lyovac products.

The lyophile technique enabled Sharp & Dohme to play a major role in World War II—the first to produce dried blood plasma for the Armed Forces. The Company was already making dried plasma commercially when it was awarded the contract to process plasma for the Government. Blood collected by the Red Cross was shipped daily, under refrigeration, to the Sharp & Dohme laboratories at Glenolden, where it was processed within 24 hours after collection. The first 15,000 units of dried plasma to be delivered to the Armed Forces were processed, as was all the blood that could be collected from large Eastern cities and handled within a 24-hour period. When the Government later asked for 200,000 units of plasma to be processed within the next year for distribution to the medical departments of the Army and Navy, Sharp & Dohme made its lyophile technique available to other manufacturers without cost.

Sharp & Dohme shared in the production of serum albumin for the Government. It also actively participated in the production of the influenza virus vaccine for the Armed Forces and has since developed and marketed an improved preparation, Influenza Virus Vaccine (Types A and B) Protamine Concentrated and Refined, which produces immunity with fewer reactions.

Crude drugs shipped to Sharp & Dohme from all sections of the world undergo 20-28 different routine checks and tests before they are shipped out as finished products. Approximately 850 different products are manufactured and made universally available through subsidiary companies in Canada, Mexico, and England, and through a network of 19 sales branches strategically located throughout the United States. Sharp & Dohme has a large force of specially trained professional sales representatives in the field, all of whom are either pharmacists or possess more than a casual education in biological sciences. They call on approximately 40,000 physicians a year to keep them abreast of new developments in drugs and their application.

Officers of Sharp & Dohme today are: John S. Zinsser, president; W. L. Dempsey, executive vice-president and secretary; Paul S. Pittenger and William A.

Feirer, vice-presidents; Fred A. Platte, treasurer-comptroller; Edward H. Frink, assistant treasurer; and Charles F. Kistner, assistant secretary. Besides Zinsser and Dempsey, the board includes: Milton Campbell, Radcliffe Cheston, Jr., Robert H. Cory, Charles D. Dickey, A. R. L. Dohme, Charles S. Garland, Howard A. Loeb, F. Grainger Marburg, G. Willing Pepper, Stanley Resor, Edward Starr, Jr., Ernest Stauffen, Jr., Philip Wallis, and John C. West.

SHARPLES CHEMICALS INC., was organized in 1926 as the Sharples Solvents Corp. for the primary purpose of exploiting a radically new process for the manufacture of synthetic amyl alcohol and amyl acetate. The principal market for these products was the rapidly expanding lacquer industry, in which they were used as solvents in nitrocellulose coatings. The nature of the Company's business changed and expanded in the following years to include a large number of synthetic organic chemicals used by many industries.

In 1923 Eugene Ayres, a chemist for the Sharples Specialty Co. (now Sharples Corp.), conceived the basic idea upon which the original process of Sharples Solvents Corp. was founded. The first step of this process (which is still used) was the synthesis of chloropentanes by continuous vapor-phase chlorination of a mixture of normal and isopentanes, a hydrocarbon fraction obtained in the rectification of natural gasoline. The products of this reaction consisted of a mixture of seven of the eight possible isomeric monochlorides of normal and isopentanes, with a small percentage of dichloropentanes. After separation of the latter, the monochlorides were hydrolyzed to a mixture of isomeric amyl alcohols which were esterified to amyl acetate (isomeric mixture).

Pilot-plant studies were conducted at Eastland, Tex., in 1924. The Sharples Solvents Corp. was incorporated in Delaware in 1926, and that year the first commercial plant was constructed at Belle, W. Va. The first tankcar of synthetic amyl alcohol (Pentasol) was shipped in December and was followed a few months later by amyl acetate (Pent-Acetate). Prior to this, the only "amyl" solvents on the market were derived from fusel oil and were lacking in uniformity. The greatest single operational difficulty at Belle, that of corrosion caused by hydrochloric acid split out during chlorination, was solved and this first plant remained in production until 1932.

In the late 1920's, the price trend of lacquer solvents was downward. Certain by-products from the synthesis of Pentasol and Pent-Acetate offered interesting possibilities, as did other synthetic organic chemicals which could be made from amyl chlorides. In 1931 the Company greatly increased expenditures for research and development of new products. In 1932 it announced Pentaphen (*p*-tert.-amylphenol), which was first of interest for germicidal preparations but later found a more important market in oil-soluble resins, and amylamine, which found application as an intermediate for the manufacture of an antioxidant. Diamyl- and triamylamines followed a couple of years later and found use as inhibitors and in the rubber industry.

In 1932 the Sharples plant was moved from Belle to its present location in Wyandotte, Mich., to insure a much more reliable and considerably lower-priced source of certain raw materials, as well as to be closer to major chemical markets. Operations began there in 1933 and a research laboratory was established. Dr. J. F. Olin, research chemist since 1930, was made director of research in 1936 and under him the research program was expanded rapidly and the staff increased to 26 in 1941. A completely new and separate research laboratory was completed at Wyandotte in 1942 and the total personnel there under Dr. Olin now totals 69. The policy of spending an above-average (for the chemical industry) percentage

of dollar sales on research and development of new products has continued since 1931 and has been responsible for the Company's expansion and diversification.

For several years the products manufactured and sold by Sharples Solvents were all derived from pentanes. In 1937, after research and pilot-plant studies, commercial production of butylamines and butyl chloride was started. Ethylamines followed in 1939 and thereafter Buramine (butylurea), diethylaminoethanol, ethylethanolamines, dibutylaminoethanol, amylphenol sulfides, metal salts of dialkyldithiocarbamic acid, tetraalkyl thiuram disulfides, and many other new products. By the first of 1943, the number of commercial products manufactured and sold by Sharples had increased from the original two to more than 60; the industries served, from only one to over 40; the number of people employed, from about a dozen to over 500. Since then, expansion of activities has increased to a point where the employees number 700.

In 1941 the Company name was changed tc Sharples Chemicals Inc., indicating more clearly the nature of the business, which for several years had been predominantly the production of synthetic organic chemicals, rather than solely solvents. That year Sharples started direct service to the war program with production of a stabilizer for smokeless powder. Other vital products were Novol diamine, an essential intermediate for the synthesis of Atabrine, and vulcanization accelerators, based primarily on amines, which had been produced several years previously. Later during the war, Pent-Acetate was used so widely for the extraction of penicillin that the amount left for other uses was almost negligible.

A number of men have played important parts in the development of Sharples Chemicals, Inc. Philip T. Sharples has been president since the Company was incorporated and its success can be attributed in no small measure to his imagination, foresight, and research-mindedness. Lee H. Clark was transferred from the Sharples Corp. in 1929 and became vice-president in charge of production a couple of years later. Under his direction the plant was moved from Belle to Wyandotte and the organization there built up. N. James Hooper, with Sharples Corp. in the early 1920's, came with Sharples Chemicals Inc., in 1927 as director of the Western Sales Division. In 1929 he was made vice-president in charge of sales. Paul Kendall first came with Sharples Chemicals as secretary-treasurer in 1927 and a few years later was made executive vice-president. Russell H. Samis, employed in 1926, was for years plant superintendent.

In 1941, when Sharples first started production of rubber chemicals, Dr. Howard I. Cramer was brought in from Akron University where he was head of the Rubber Department. He was advanced to director of development in 1944 and under him several new products have been developed that are just now ready commercially.

In Jan. 1944 the executive offices were moved from the original location at 23rd and Westmoreland Sts. to 123 S. Broad St., Philadelphia. Sales offices are maintained in the Empire State Bldg., N. Y. City, and at 80 E. Jackson Blvd., Chicago. Most of the selling is done by the Company's own Sales Department, although the West Coast area is covered by Martin, Hoyt & Milne. In Canada, Sharples products are sold by Shawinigan Chemicals Ltd., and in 1945 an arrangement was made with Airco Export Corp. to handle foreign sales.

Late in 1946, Sharples-Continental Corp. was formed as a wholly owned subsidiary of Sharples Chemicals Inc., and Continental Oil Co., for the purpose of manufacturing petroleum chemicals. The first production unit is located in Baltimore, at the site of a former Continental Oil refinery. It makes nonylnaphthalene and dodecyltoluene, raw materials for wetting, washing, and emulsifying agents of the alkylarylsulfonate type. These hydrocarbons are sold by Sharples-Continental

Corp. under the trade name, Neolene. This new company brings together the resources and facilities of Continental Oil Co., one of the major producers, manufacturers, and marketers of petroleum products, and Sharples Chemicals Inc., pioneers in the synthesis of chemicals from petroleum and other sources.

SHAWINIGAN CHEMICALS LIMITED grew from the Shawinigan Water & Power Co. of Montreal, which was approached by the Imperial Munitions Board at Ottawa, early in 1915, with the request that it consider the manufacture of acetone, the solvent for the official British propulsive explosive, cordite, from acetylene by a process outlined in certain German patents. At this time the Power Co. was operating in Shawinigan Falls, Quebec, a plant with a capacity of 40,000 tons of carbide per annum.

H. W. Matheson, a native of Nova Scotia and graduate of Dalhousie University and at that time employed by du Pont, was retained by Howard Murray, director of Shawinigan Water & Power Co., and brought to Shawinigan Falls to supervise the construction and operation of a projected pilot plant to test out these processes. Matheson arrived in Oct. 1915, and in December was joined by H. S. Reid, a recent graduate in chemistry of McGill University.

On Dec. 1, 1915, the Canadian Electro Products Co. was formed, as a wholly owned subsidiary of the Shawinigan Water & Power Co., to produce acetone from carbide for the British war requirements. The first directors were, J. C. King, Murray, Matheson, Julian C. Smith, and R. A. Witherspoon; the officers, Murray, president; Smith, vice-president; James Wilson, secretary-treasurer. Now began, in a dingy, dusty old building known as "The Fort," situated in the yard of the carbide plant, the first stirrings of what was to become a most important contribution to the synthesis of organic compounds from acetylene. At this time the chief use of acetylene was as an illuminant. The art of cutting and welding metals with oxyacetylene flame was just emerging.

Early in 1916, Victor G. Bartram, now president of Shawinigan Chemicals, was transferred from the Purchasing Department of the Power Co. and became general purchasing agent for Canadian Electro Products, in charge of equipment. Acetylene was hydrated to acetaldehyde in Duriron equipment, and enamel-lined kettles were used for the oxidation of acetaldehyde to acetic acid. Since delivery of a liquid-air plant to supply oxygen was delayed, air under pressure was substituted and proved so successful that this method of oxidizing acetaldehyde remains in use today. As the mercuric oxide catalyst for the hydration was unobtainable in the quantities needed, Dr. Colin G. Fink of Columbia University was retained to design an economic process for the large-scale oxidation of mercury. He recommended anodic oxidation in alkaline solution. Manganese acetate was selected as the catalyst for the oxidation of acetaldehyde.

Matheson's search for chemists to operate these various units on a 24-hour schedule resulted in the arrival, May 8, 1916, of A. F. G. Cadenhead from Queen's University, Kingston, Ont., to join Reid whose enthusiasm, curiosity, and energy were infectious. Files of German patents were studied although it was known that a company near Buffalo, N. Y., in attempting to work these patents, had very successfully blown its building and equipment to bits and had given the matter up as a bad job. About the middle of May, Waldo C. Hovey and Frank H. Andrews arrived from McGill and these four Canadian chemists, Reid, Cadenhead, Hovey, and Andrews, under Matheson, also a Canadian, began the gigantic task of operating a large pilot plant—the word had not yet been coined. Such processes were unchartered waters then.

As the details of each process were worked out, large-scale equipment was

designed and ordered, mainly from the United States, for the big plant being built by Church Ross & Co., contractors, of Montreal. Frequently, due to high-pressure experimental work, equipment was scrapped as obsolete before installation. Mechanical difficulties were more numerous than the chemical. The plant was designed to produce 10 tons of acetone daily, requiring 25 tons of acetic acid or approximately 50 tons of carbide. A 50-ton carbide furnace was designed and constructed by the Canada Carbide Co. On Nov. 20, 1916, the first batch of five tons of acetic acid was produced and during Jan. 1917 the first carload of 17 long tons of British War Office specification acetone left the yard. In less than nine months, a most complex and difficult job had been done. During part of 1917, 1,200 long tons of acetone were shipped, but in the autumn, the demand for acetic acid for making cellulose acetate for airplane dope closed down the acetone process. Approximately 10,000 long tons of glacial acid were shipped to England by the time of the Armistice.

When the United States entered the war, the demand for acetic acid necessitated contruction of a duplicate of Canadian Electro Products, known as the American Electro Products Co. The Armistice was signed before production could begin and the plant was ultimately acquired by Canadian Electro Products. Then followed lean years for the chemical company, and during this period the long-view policy of the directors, Julian C. Smith and Howard Murray, kept the key research men at work. Processes were enormously simplified, resulting in greatly lowered costs and placing the Company in an enviable position when the commercial revival came.

At this time Philip H. Falter, formerly with the Aluminum Co., joined the Company as general manager. In association with J. E. Aldred, he had established at Baltimore the ferrosilicon process and plant known as the Shawinigan Electro Products Co. In the immediate postwar readjustment period, however, Canadian Electro Products had lost its only customers for acetic acid, and about Jan. 1, 1919, it ceased operations. But the plant which stood on the books of the Company at a value of $2,500,000 was not scrapped. At this time the two Dreyfus brothers, Camille and Henry, were creating a stir in France and England with their cellulose acetate fibers and films. The directors, partly on this account, and for other reasons retained their technical staff, and put them on "plant research." After the explosion on Dec. 10, 1918, which completely demolished the acetaldehyde building and its equipment, Reid and Hovey commenced the work which eliminated the mercury oxidation process and culminated in the present method of making the mercuric sulfate catalyst in much improved and simplified equipment.

In the 1923 report of the Shawinigan Water & Power Co., the combined business done by the Canada Carbide Co. and Canadian Electro Products was recorded as being $3,300,000. In 1926 Shawinigan announced that the two companies formed one of the greatest chemical groups of its kind in the world and that its position was an outcome of the intensive study and research devoted to its problems since the Armistice.

In 1919 Shawinigan Ltd., was formed in London with H. E. Mussett as managing director since 1922 and chairman since 1938. It distributes products of Shawinigan Chemicals Ltd., in England and Europe, Shawinigan Products Corp. was formed early in 1920 in N. Y. City, under L. F. Loutrel to handle Shawinigan products in the United States. In addition to Loutrel, the officers were Julian C. Smith, president; James Wilson, secretary-treasurer; Gerard H. Murphey, assistant secretary-treasurer.

In 1922 the U. S. Government placed an import duty of $20 per ton on carbide, but next year Shawinigan Products, through a contract with the United Lead Co.,

subsidiary of the National Lead Co., acquired an interest in a small carbide plant at Keokuk, Ia., where an extremely high-grade product was made. This same year, a contract was made with the Swann Chemical Co. to sell its carbide production of Anniston, Ala. At the end of 1926 carbide sales had grossed 20,000 tons per annum. In 1927 W. S. Hart took over the presidency of Shawinigan Products, becoming chairman of the board in 1940, when L. F. Loutrel, succeeded as president; Henry Booth, vice-president; and Gerard H. Murphey, secretary-treasurer.

In 1929 the Midwest Carbide Corp. was formed to round out the interests of both the subsidiary and the Lead Co. at Keokuk. In 1932 the offices of the company were moved from 110 William St. to the Empire State Bldg. While one lean year followed another, at no time were they so lean as to bring about red figures. This was due largely to the development, at Shawinigan Falls, of new products, such as acetylene carbon black, vinyl acetate, and vinyl resins.

In 1927 American Electro Products Co. finally became a part of the Canadian Electro Products Co., which was consolidated with the Canada Carbide Co., Dec. 3, 1927, to form the new company, Shawinigan Chemicals Ltd. Both units retained their original charters. The first officers and directors were: Julian C. Smith, president; W. S. Hart, 1st vice-president; R. A. Witherspoon, H. S Reid, H. W. Matheson, and V. G. Bartram, vice-presidents; James Wilson, secretary-treasurer; and Howard Murray. Anticipating the rapidly growing demand for acetic acid, the Company greatly increased its capacity during 1928. The Carbide Division built its largest furnace No. 5, a 25,000-kw. unit with a capacity of 200 tons of carbide per day; furnaces 3, 4, and 5 ran to capacity during 1929 and the early months of 1930.

The Plant Research Department, with Cadenhead as director, was formed in 1929 to continue the study of the various processes. Discovering that acetic anhydride was recoverable from the acetic acid process, the Company went straight into full-scale operation and was the first to make anhydride in commercial quantities by this new method, at a time of heavy demand by the cellulose acetate silk industry. However, much of the acetic acid business was lost through licensing others to operate the process in economically more advantageous areas. Notable new products developed during this period were acetic acid esters, which found a ready market as solvents in the paint and varnish industry, and acetone was made by an entirely new process.

Experimentation was started on Shawinigan acetylene black by Stuart A. Wisdom in 1918. The furnace design decided upon persists today. The product's major market is in dry batteries or flashlight cells, but it was 15 years after invention before consumption reached any magnitude. Present capacity is only a few million pounds per annum, but the black has been an important factor in the war effort.

An outstanding achievement of the original research under Matheson was the development of the polyvinyl resins Gelva, and the acetals Formvar, Alvar, Butvar, and Benvar. George O. Morrison, in charge of converting ethylidene diacetate into acetic anhydride, had saved certain by-product residues, one of which, upon the insistence of the late Dr. F. W. Skirrow, chief chemist, was identified as vinyl acetate. A year later, a five-gallon sample was found to have polymerized to a clear-crystal glass. Morrison immediately embarked on a study of vinyl acetate and developed the process for its production. K. G. Blaikie worked on its polymerization (July 1926) and patents were issued to Skirrow, Morrison, and Blaikie (assigned to the Company), which are basic in the field of vinyl resins.

Late in 1928, in a further effort to make an acetaldehyde-phenolic resin, it appeared that the acetals were formed rather than phenolics. Formvar was the first in which it was accidentally discovered that polyvinyl acetate was hydrolyzed, leav-

ing a polyvinyl alcohol, and that formaldehyde replaced the acetate groups on the -OH radicals. A few days later, and all on the same day, Alvar, Butvar, and Benvar were produced. Basic patents were obtained by the Company and the process licensed to large chemical companies in the United States. The Shawinigan Resins Corp. was formed in 1937 jointly by Shawinigan and the Fiberloid Corp. to manufacture and distribute these resins. It was shortly thereafter taken over by Monsanto's Plastics Division which produces for the United States market chiefly the acetal Shawinigan resins Butvar and Formvar.

The Canadian Resins & Chemicals Co. was formed jointly by Carbide and Carbon Chemicals Corp. and Shawinigan Chemicals in 1941 to manufacture the copolymer vinyl chloride and vinyl acetate known as Vinylite, and the acetals Formvar, Alvar, and Butvar from Shawinigan Gelva, for the Canadian and export market. The directors were: J. A. Rafferty, chairman; V. G. Bartram, president; H. S. Reid, J. G. Davidson, H. W. Matheson, and J. W. McLaughlin, vice-presidents. J. A. Fuller was treasurer and J. H. F. McCarthy, secretary. The entire production during the war was allocated to the Canadian Government for waterproofing uniforms. The plant, which has a capacity of 4,000,000 lb. of resin per year, is located at Shawinigan Falls, with W. C. Heidenreich in charge. A large fabricating plant built during 1945 is now producing, for the Canadian market, films and sheets in rolls, and granular resin for the fabricating and molding trade. Canadian Resins sells all Shawinigan artificial resins in Canada and Great Britain. The Sales Department in Montreal is in charge of J. Southwell.

When the Second World War broke out, Shawinigan Chemicals built two large carbide furnaces, one for the British and one for the U. S. Government, at a total cost of about $5,000,000. In all, seven carbide furnaces were operated, with production totaling 250,000 tons annually, the largest single carbide plant in the world. A plant for the production of monoethylaniline and another for butyl alcohol were erected and operated by the Company for the Government.

But the outstanding war achievement was the development of the superexplosive RDX. Methite was the local name given to the product, and the company formed to manufacture it was the St. Maurice Chemicals Ltd. Late in 1940 Dr. J. H. Ross of the Department of Munitions & Supply and McGill University, commenced work on RDX. At approximately the same time Dr. G. F. Wright of the National Research Council and the University of Toronto began working along similar lines, improving the existing English process. Ross' work showed the way toward a new type of chemical reaction. The U. S. National Defense Research Council was informed of Ross' discovery, and various United States scientists went to work on it. Dr. W. E. Bachmann of the University of Michigan conceived the idea of combining the Wright and Ross processes.

About May 1, 1941, Dr. Ross approached Shawinigan Chemicals to develop his process through the pilot-plant stage. This work was done by Gwyn Benson and H. S. Sutherland. By December, the Canadian Government had approved construction of an RDX plant by the Ross process, and the U. S. Government had approved the Woolwich (English) process to cover about 25% of its requirements, the other 75% to come from the Bachmann process, not yet fully developed. Bachmann's process had been given to the Western Cartridge Co. of East Alton, Ill., to develop, without much success. In the meantime Wright had adapted the Bachmann process to use liquid feeds, thus opening the way to a continuous process. By Jan. 1942, the U. S. Government had given the Tennessee Eastman Corp. the problem of recovering acetic acid from the Bachmann process and developing the process. This, as modified by Wright, proved successful and Shawinigan changed to it, production beginning July 19, 1942. H. S. Sutherland was manager of this

plant. Before the end of the war, production was 350 tons per month. Tennessee Eastman came into big-scale production about May 1943. Its final production rate was 20-25 times that of the Canadian plant.

Labor trouble during the life of the Company had been virtually unknown. Aside from the fine type of labor, happily situated at Shawinigan Falls, the chief raw materials of Shawinigan Chemicals for the manufacture of calcium carbide, are strongly suggestive of the four "elements" of the ancient alchemists: fire (the electric arc), water (water), earth (limestone and coal), air (air or oxygen). All except the coal are close at hand and bituminous coal is still plentiful in Nova Scotia by water-borne freight to within 20 miles of the factories.

SHELL CHEMICAL CORPORATION, like the related research organization, Shell Development Co.. was founded to build a chemical industry based on petroleum. This diversification of the petroleum industry into the chemical field was logical not only in view of the abundant source of hydrocarbon raw materials, but in the light of evident moves of the German chemical industry to manufacture gasoline by way of coal hydrogenation and other synthetic processes.

The Company was incorporated, Feb. 18, 1929, with the support of N.V. de Bataafsche Petroleum Maatschappij. Officers were Herbert R. Gallagher, president; D. Pyzel, vice-president; Edward Hepner, secretary; and John Lauder, treasurer. The two principal objectives were: first, to utilize natural gas by high-temperature cracking as a source of hydrogen for synthetic ammonia; second, to utilize the constituents of refinery cracked gases as a source of alcohols, ketones, and other chemicals, bringing into commercial production the fruits of Shell Development's research on chemical derivatives of propylene, butylenes, and other light hydrocarbons.

A nitrogen-fixation plant was built in 1930-31, about 30 miles northeast of San Francisco near Pittsburg, Calif., since known as "Shell Point." This location was chosen because of the availability of natural gas (pipe line from central California fields to the San Francisco area), its closeness to rail and water transportation, and its strategic situation in an intensively agricultural area. This was the first synthetic ammonia plant of any size in the West. The synthesis is by a modification of the low-pressure Mont Cenis process.

Part of the original production of ammonia was sold in bulk to a near-by explosives manufacturer for conversion into nitric acid, and beginning in 1933, also in cylinders for refrigeration, etc. The major portion was converted into ammonium sulfate for fertilizer, although this was under severe competition from Japanese and European producers who entered the Pacific Coast market just at that time (in 1931 the price of ammonium sulfate dropped from over $40 per ton to $24, and the price remained at or below this figure for several years). That the Company was able to carry on may be attributed to the tenacity of its founders and of Cornelis B. de Bruijn, president from 1931 until his retirement in 1941, and S. S. Lawrence, sales manager, and to a succession of technological developments, including the successful use in sulfate manufacture of waste sulfuric acid from oil refinery and alcohol plant operations, a steady increase in yield of ammonia per unit of natural gas entering the cracking furnaces, and the discovery and commercial application of the direct use of anhydrous ammonia as a fertilizer.

The last advance took place in two steps. First was the metering of ammonia into irrigation waters, developed by Ludwig Rosenstein, then chief chemist, and Felix Kortlandt, also of the Shell Chemical staff; Dean D. Waynick and F. H. Leavitt of the Association Laboratory; and Paul Greening of Greening-Smith Co. It proved particularly useful in the large irrigated farms and citrus groves of

California and Arizona. Later a methol was devised by Leavitt, who had by then joined Shell Chemical, for injecting ammonia directly into soil during tillage, using a simple attachment to conventional farm implements. The principal by-product of the ammonia plant, carbon black, is used in rubber and steel manufacture.

The second objective of Shell Chemical, to utilize constituents of refinery cracked gases, has been pursued actively from 1930, when a small semicommercial plant producing secondary butyl alcohol from n-butylenes was placed in operation adjacent to the Martinez refinery of Shell Oil, also a few miles northeast of San Francisco. A year later operations were expanded to include tert. butyl alcohol and methyl ethyl ketone. In 1935 isopropyl alcohol and acetone were added. The improved procedures introduced at the Martinez plant were incorporated into the basic design of the next plant, which was built adjacent to the Wilmington-Dominguez refinery of Shell near Los Angeles. The Dominguez plant, completed in 1936, initially made the same alcohol and ketone products, followed by diacetone alcohol, mesityl oxide, and methyl isobutyl ketone. The way was thus opened to still further products, derived from diacetone alcohol by another line of attack, leading to hexylene glycol (methylpentanediol), methylpentadiene, and dimethylsulfolane, recently placed in production at Martinez. Important uses of each of these, respectively, are as a constituent of hydraulic fluids, in the manufacture of high polymers, and as a selective solvent.

In its manufacturing operations Shell Chemical, because of its close affiliations with oil refining, has drawn heavily upon petroleum processing techniques. Yet even early in its history, the know-how developed in its chemical operations became of vital importance to the oil industry, notably in the synthesis of special components of petroleum products, especially high-octane gasoline. Processing techniques developed in the manufacture of alcohols by acid absorption of olefins proved indispensable in the development of the process for isoöctane, which in 1934 made possible the first commercial production of 100-octane aviation gasoline. Shell Chemical's knowledge of the manufacture and use of hydrogenation catalysts was also drawn upon for this development. The isoöctane synthesis, limited to isobutylene as olefin source, soon gave way to the hot-acid polymerization process, which utilized both isobutylene and normal butylenes, and finally to the sulfuric acid alkylation process which brought the saturated hydrocarbon, isobutane, into the 100-octane picture.

In 1940 Shell Chemical undertook the manufacture of chemicals from refinery cracked gases at Houston, Tex. Initial products included acetone and isopropyl alcohol, but this plant was especially noteworthy as the commercial follow-up of pioneering prewar research by Shell Development on the production of butadiene. Construction was started early in 1941 and the plant went on stream in Sept. 1941. It was the first full-scale butadiene plant in the nation. It produced more butadiene in 1942 than any other plant, the process used being chlorination of butylene at moderate temperature, followed by pyrolysis of the dichloride. Owing to the wartime shortage of chlorine, this process was not adopted for the Government program; however, Shell Chemical undertook for Rubber Reserve the design and construction at Torrance, Calif., of one of the largest butadiene units under this program, with a capacity of 60,000 tons per year, and placed it on stream in July 1943. In addition to direct operation of these butadiene plants, Shell Chemical contributed process and research information to other plants in the country's synthetic rubber program.

As a result of its research discoveries in the field of gasoline additives, Shell Chemical was requested early in 1943 to convert the incomplete Cactus Ordnance Works, a synthetic ammonia plant in the Texas Panhandle, for production of un-

precedented quantities of xylidines for use as high anti-knock blending components of aviation gasoline. The conversion was completed in six months, in time to relieve substantially the shortage of highest quality aviation fuel for the stepped-up operations of the Air Forces at a critical period.

At the request of the War Production Board, units were constructed in 1945 at Houston for the manufacture of allyl chloride, allyl alcohol, and a mixture of chlorinated propylenes trade-named D-D, employing the Shell Development process of substitutive chlorination of olefins at high temperatures. The chloride and alcohol were principally required for preparation of certain pharmaceuticals and low-pressure laminating resins, respectively. D-D had been found exceptionally effective as a soil fumigant for the control of nematodes and certain other soil-borne pests, and was required as an aid to increased food production. More recently several related chemicals have been placed in production, including acrolein, epichlorohydrin, and glycerin dichlorohydrin. Plans are now being completed by Shell Chemical for the first commercial production of synthetic glycerin, utilizing the same substitutive chlorination process. This is a major accomplishment and will have a stabilizing influence on the heretofore highly fluctuating glycerin market. In 1946 Shell Chemical introduced Shell 105 catalyst which permitted continuous dehydrogenation of butylenes at high yields and conversions for long periods without requiring frequent regeneration. It has been adopted in all petroleum butadiene plants operating under the Government program.

On Oct. 1, 1943, Shell Chemical Co. was liquidated and merged into the Shell Union Oil Corp., and operations thereafter were continued as a division. On Jan. 2, 1946, Shell Oil Co., Inc., acquired the Shell Chemical Division which became a subsidiary of Shell Oil, with the name Shell Chemical Corp. Today Shell Chemical is an integrated organization employing over 1,900 persons, with its head office in New York City and with four large operating plants exclusive of the government-owned butadiene plant at Torrance, Calif. Marketing offices are located in several principal chemical-consuming centers. The Company is headed by Jan Oostermeyer, president; William P. Gage, vice-president of manufacturing; Leo V. Steck, vice-president of marketing; and A. G. Schei, treasurer. George R. Monkhouse is general manager of the Western Division, which has its principal office in San Francisco, and is in charge of all marketing operations west of the Rocky Mountains. Plans for expansion into new fields of petroleum derivatives are going forward in pace with research developments and the expanding requirements of agriculture and chemical-consuming industries.

SHELL DEVELOPMENT COMPANY, organized in June 1928 as a subsidiary of the Shell Union Oil Corp., was the crystallization of the ideas of Sir Henri Deterding, J. B. August Kessler, and Daniel Pyzel to found a chemical industry based upon petroleum. It was hoped that oil and petroleum gases would prove as important a source of chemicals as coal tar.

The first officers were: H. R. Gallagher, president; Pyzel, vice-president; G. C. Noble, secretary; and John Lauder, treasurer. The director of research chosen was E. Clifford Williams, then in charge of the Ramsay Laboratory of Chemical Engineering, University of London, and active in the field of coal-tar derivatives. From Dec. 1936 until his resignation in Dec. 1940, Williams was also vice-president in charge of research. Reflecting the second major purpose of the Company, to engage in fundamental research of value in oil refining, Shell Development was legal successor to the Simplex Refining Co., owners of the Trimble and other patents in the oil-refining field. The chemicals to be developed would be manufactured by Shell Chemical Co.

Research laboratories comprising about 27,000 sq. ft. were completed Oct. 1928, at Emeryville, Calif., on the shores of San Francisco Bay. This location was near important oil fields, convenient to the principal offices of an operating oil company and to one of its refineries, close to the University of California and Stanford University, and had the further advantages of attractive near-by residential communities and an excellent working climate. The laboratory staff, which was 35 at the close of 1928, grew to over 200 by 1935, and over 400 by 1938, when a four-story administration and laboratory building was erected. The original site was supplemented in 1935 and 1939 and by 1946, when the staff numbered about 1,000, it totaled over 188,000 sq. ft.

Administrative offices, Patent Department, and Engineering Department were established in San Francisco. Antoine E. Lacomblé, now president, serves also as director of research; Ava J. Johnson, vice-president, is in charge of engineering; Dan M. Sheldon, vice-president and secretary, administrative matters; Bernard J. Gratama, assistant secretary, manager, Patent Department; and J. Howard White, vice-president and treasurer. In New York, vice-presidents Hiram Norcross, Jr., and Monroe E. Spaght and their staff handle licensing of Shell patents and developments to other companies, and arrangements for reciprocal cooperation. The Engineering and Patent Departments, originally directed by Frederic B. Pyzel and B. J. Gratama, respectively number over 100 and over 40 members.

The organization of the Emeryville research laboratories is a natural evolution, based upon the work of individuals who were grouped about outstanding investigators. These groups eventually developed as departments under the general guidance of A. E. Lacomblé, and the associate directors of research: Theodore W. Evans, manager; Otto A. Beeck, Physics; Karl R. Edlund, Market Development; David L. Yabroff, Process Development; Bernard S. Greensfelder, Catalytic Refining; Sumner H. McAllister, Petroleum Technology; Miroslav W. Tamele, Colloid Chemistry. The remaining research departments are: Organic Synthesis, Coating Materials, Spectroscopic, Motor Laboratory, Physical Chemistry, Asphalt, Lubricants and Gasoline, Analytical, Instrument and Glassblowing, Analytical Standardization, Reaction Kinetics, Corrosion, and Organic and Applications.

The initial researches dealt with the chemical utilization of refinery waste gases. The first process developed through semiplant scale was the manufacture of sec.-butyl alcohol (1930); this was placed in commercial operation by the Company, at Martinez, Calif., the same year. In 1931 the synthesis of methyl ethyl ketone was developed through semiplant scale, leading to the first commercial manufacture of this ketone as such. These products were followed by other alcohols and ketones derived from the lower olefins. As a consequence of this activity, market development research was undertaken in 1932 under the direction of Leo V. Steck, now a vice-president of Shell Chemical. From the process for separating isobutylene from the other butylenes needed for sec.-butyl alcohol manufacture came diisobutylene, which gave isoöctane by hydrogenation. Meanwhile attention was given to problems of oil-refining technology, and this was considerably expanded in 1933 with the entrance into the organization of S. Tymstra, an associate director now retired, who had been associated with the refining operations of various Shell companies. The following year fundamental physical research was undertaken under the direction of O. Beeck, and in 1935 departments were created for oil production research under Albert G. Loomis, and for research on the applications of chemical products, under W. J. Hund.

Pioneering research on chlorinated derivatives of the lower olefins, particularly allylic compounds and their derivatives, was by this time quite active. Methallyl chloride was developed on semiplant scale in 1935 and the first semiscale produc-

tion of allyl chloride and allyl alcohol was achieved in 1936. These allyl compounds, including D-D mixture (a soil fumigant), epichlorohydrin, and glycerin dichlorohydrin, are now being produced commercially by Shell Chemical. The preparation of allyl chloride by high-temperature chlorination opened up a new field of chemical development, since prior to this the possibility of substitutively chlorinating such olefins as propylene had been unknown. A direct outgrowth was the first production of synthetic glycerin from petroleum. This was carried through pilot-plant operation in 1937 and a commercial plant is now (1948) being operated by Shell Chemical.

The early production of butadiene at Emeryville on semiplant scale, leading to a Shell plant placed in operation just before Pearl Harbor, was of much value in the early development work of the rubber companies. This was the result of studies of the moderate-temperature chlorination of butylene and pyrolysis of the resulting dichloride, which had reached the pilot-plant stages in 1938. Recovery and refining of petroleum alkyl phenols (cresylic acids) was developed in 1936 and led to pioneering commercial production by Shell Oil the following year.

The "solutizer" treating process for the extraction of mercaptans from gasoline by a mixture of alkali and organic solvent was developed in 1936-37; the phosphate process for removal of hydrogen sulfide from gases, in 1937. Study of the conversion of lower ketones into their condensation products led to the pilot-plant production of diacetone alcohol in 1936, and of mesityl oxide and methyl isobutyl ketone in 1938.

Following the early processes of isobutylene polymerization plus hydrogenation, the alkylation process was developed jointly by Shell and others, and brought to commercial operation in 1939. It produced high anti-knock paraffins from isobutane and olefins directly, and in still larger quantity for a given amount of olefin. Studies of the vapor-phase isomerization of butane, to break the bottleneck of isobutane supplies for the alkylation process, were carried to pilot-plant scale in 1939. A liquid-phase isomerization process was later developed. All these processes were used extensively by Shell and some also by other oil companies. Another aviation fuel component was made available in 1942 with the development of processes of alkylating benzene with propylene to form cumene. Details of one of these processes were made available without charge to the oil industry to facilitate production of cumene. In these developments the motor laboratory, established in 1937, evaluated potential products, suggesting effective structures for synthesis. Thus the exceptional performance of cumene in supercharged aircraft-type engines had been found in the course of motor laboratory research, and led to it synthesis. This development alone made possible some 25% of the increase in the country's 100-octane gasoline output for 1942-43.

The urgent need for nitration-grade toluene in 1939 led next year to its recovery by extractive distillation, and the next two years to a selective isomerization-dehydrogenation process for its synthesis from refinery naphthenes. The recovery process was used for the production of over 40% of all the petroleum-derived toluene produced in this country during the war. The synthetic process was employed in two large Shell Oil plants, beginning in 1943. Together they contributed very substantially to the increase in total toluene production, which ultimately grew to tenfold what would have been possible from coal tar alone.

In the butylene dehydrogenation process employed in the government-sponsored butadiene plants, three separation processes developed at Emeryville have been used. A Shell Development catalyst which makes regeneration unnecessary was adopted in 1946 in all these plants. The laboratories also contributed rapid gas and spectroscopic analytical methods for efficient plant control.

The corrosion research laboratory, established in 1938, has been active in almost all phases of petroleum technology. Two outstanding developments are an inhibitor for protection of gasoline pipe lines from internal corrosion (1939) and a vapor-phase inhibitor for rustproofing steel in a container or package without either coating the steel or rigorously excluding moisture. In 1946 the latter won the U. S. Naval Ordnance Development Award.

Fundamental research is strongly emphasized at Emeryville because of its importance in furthering basic advances in technology. In the field of petroleum production this research has led among other things to the successful acid-solvent treatment of oil wells (1936), improved water-base drilling fluids (1936), improved methods of analyzing drilling cores (1938), advances in knowledge of oil field flow (1938), and improvements in oil-base drilling fluids (1942). This research was transferred in Dec. 1945 to a new Shell Oil laboratory in Houston, Tex., which is closer to field operations.

Because of its experience in separation processes, Shell Development was invited by the War Production Board in 1944 to participate in a government-sponsored emergency effort to find means of increasing the then seriously inadequate capacity for penicillin. A process was developed during 1944-45 which surmounted separation difficulties to the extent that both recovery and product purity were markedly increased, and the process is now used in one or another form by several manufacturers of penicillin. Similarly Shell Development participated actively in a government-sponsored cooperative effort to establish the molecular structure of penicillin by chemical and spectroscopic means, with a view to possible synthesis. Other special cooperative war projects included the development of vehicle-mounted flame-throwing type weapons, the study of gasoline storage stability under desert conditions, and the investigation of various aircraft fuel and lubricant problems.

SHERWIN-WILLIAMS COMPANY has been producing high-quality paints, varnishes, lacquers, insecticides, chemicals, etc., for 80 years. In July 1866, Henry A. Sherwin, then 24, joined in partnership with Truman Dunham to sell white lead, linseed oil, colors, brushes, glass, etc. Then very little ready-mixed or prepared paint was on the market. Mixing paint was practiced only by professional painters. D. R. Averill of Newburg, a suburb of Cleveland, in 1867 invented a ready-mixed paint which would not settle in the package, but he did not use materials which would cover or wear well. Sherwin would have nothing to do with such ready-mixed paint, but realizing the possibilities of the prepared paint business, he left his partnership with Dunham to go into the manufacture of paints himself.

In 1870 he was joined by Edward P. Williams, part owner of a glass-manufacturing company which sold glass to Truman Dunham & Co. They became partners under the name of Sherwin, Williams & Co., starting with a modest capital of $2,000. In 1884 this partnership became the Sherwin-Williams Co., whose present capital and surplus surpass $60,000,000. The partners in 1873 bought from the Standard Oil Co. an old one-story cooper shop on the site of the present Cleveland plant. Their first paint-making machinery consisted of one secondhand stone mill and a putty chaser. Through successive plowing profits back into the business and bringing in additional capital, the manufacturing facilities now embrace 32 plants in the United States, Canada, and South America, occupying some 700 buildings. The trained chemical staff which started with one chemist, Dr. Percy Neyman, M.I.T. graduate hired by Henry Sherwin, now includes several hundred.

Until 1898 manufacture was confined to paint, then merely a mechanical mixture of pigments with oils or varnishes. The Cleveland factory, however, operated

a department for refining, boiling, and otherwise treating linseed oil and for manufacturing driers, grinding Japan, and other items. The products marketed included a complete line of oil paints for the exterior of houses and buildings—flat, semigloss, and enamel paints for interiors. A wide variety of paints was supplied to railway and steamship companies, and to manufacturers of vehicles, agricultural implements, and many industrial products. This development of paints and varnishes was under the direct supervision of J. C. Beardslee, who joined the staff in 1880 and served as general superintendent, 1886-1910, continuing as a director. He was much interested in all manufacturing problems until his death in 1928.

During these years paint and varnish formulas were greatly improved. Laboratories were established in all plants and extensive research was conducted for many years at Chicago. Here finished products are tested, besides being subjected to field exposures in Florida and elsewhere. During recent years many new products have been developed. One of the most outstanding is Kem-Tone, a water-miscible synthetic resin emulsion paint for interior use over wallpaper, plaster, or painted walls. Innumerable paint, enamel, and varnish products have been especially developed for individual household requirements; for manufacturers of automobiles, furniture, machinery, and many other products; for railroad-car builders and shipbuilders. During both World War I and II, enormous quantities of paint and similar products were supplied to the War and Navy Departments and to manufacturers of equipment, ammunition, and all other military requirements. The Company's chemists also assisted government departments in the development of new products to satisfy exacting specifications for unusual war conditions.

The first departure from simple paint manufacture was in 1898 when the production of varnishes for household and industrial use was undertaken. These were made from natural resins, vegetable oils, and turpentine or mineral spirits. Since then natural resins have been displaced by synthetic resins and a wide variety of new oils and reducers have been introduced, yielding protective coatings far surpassing the early simple finishes. These chemical developments were supervised by E. C. Holton, an M.I.T. graduate and chief chemist from 1892 until his death in 1934. He worked very closely with J. C. Beardslee in research covering paint and varnish, raw materials, and new formulas. As the business grew, he supervised all chemical research, including paint, varnish, lacquers, dry colors, dyes and intermediates, and insecticides, contributing much to the Company's growth. In his later years, Holton was assisted by Dr. C. D. Holley who joined the Acme White Lead & Color Works in 1907 and came with Sherwin-Williams when it absorbed Acme in 1920. From then until his death in 1942, he supervised all paint formulas to bring them up to the highest Company standards.

Sherwin-Williams' real entry into the chemical industry came about in 1896 when the manufacture of dry colors was undertaken in a pilot plant at Cleveland, under Holton's direction. The first product was red lead eosin vermilion. In 1901 a large dry-color plant was erected and production of *p*-nitroaniline and toluidine reds was begun under H. M. Ashby. A large volume of such reds went to agricultural implement manufacturers. Inorganic colors, including lead chromate yellows, chrome greens, iron blues, etc., and many organic lakes, were also marketed. The Cleveland plant was soon outgrown and in 1903 a much larger one was erected at Chicago, to which the production of dry colors was moved.

With the outbreak of World War I, a department was established for the manufacture of aniline dyes and intermediates which had been imported from Germany. This has grown to be one of the Company's major divisions. At the same time the Color Department, now under the supervision of M. B. Doty, had been greatly enlarged, many new products added, and former colors much improved.

The standards of five years ago are no longer considered satisfactory. Today shades and tints are much stronger, colors have much greater light resistance, opacity is much more dense, texture permits a more rapid rate of grinding. Great progress has been made in the manufacture of benzidine yellows ever since domestic production started about 15 years ago. The present standards are much better than foreign competition. Molybdate orange, which was first marketed about 10 years ago, is proving to be a very valuable color. Chrome greens today are much more permanent to light and grind much more easily than those of the 1930's. Phthalocyanine blue, produced about 10 years ago, is the most outstanding blue color development during the last 100 years, combining a high degree of all desirable properties with none of the disadvantages previously known in blue pigments.

For many years research had been conducted attempting to produce dispersed or paste colors direct from dry-color pulp without resorting to the process of drying out the water, breaking up the lumps into a powdered dry color, and then mixing in oil or varnish. This effort was successful in 1929, when a complete line of dispersed colors and flushed inks was put on the market. Sherwin-Williams is today one of the leading producers of fine pigments for the paint, lacquer, printing ink, floor covering, rubber, and allied industries.

When the Company decided to manufacture intermediates and dyes in 1914, the first attempt was at β-naphthol, in the Dry Color Department at Chicago, by superintendent R. V. Brown. It was soon found that the complicated manufacturing process was more than could be handled by the staff, so a Chemical Products Department was organized, which began to expand very rapidly. New men were brought in and a great deal of money was invested in plant, under the general supervision of H. J. Hain. Walter H. Cottingham, president at that time, was the guiding force of this effort and the entire program soon progressed successfully. He was instrumental in organizing the American Dyes Institute which brought together many chemical companies which had also undertaken to manufacture dyes and intermediates no longer available from abroad.

During the early war period the Company entered into the whole general organic color and intermediates field, which meant that a great many intermediates were made, including nitrobenzene, dinitrobenzene, aniline, nitrotoluenes, phenylenediamines, etc. The character of the Company was radically changed from that of a "Paint House." Many chemists were employed, including Dr. N. E. Van Stone who became and for many years has been in charge of all chemical development and manufacture. He succeeded Dr. Ney, a Swiss chemist experienced in the manufacture of dyes and intermediates in Germany, who for three or four years had direct charge of this development. W. A. Miller, L. E. May, and C. E. Deeds were among the other chemists employed.

The Sherwin-Williams Co. became one of the leading manufacturers of basic raw materials for the organic pigments industry. The major products were β-naphthol, *p*-nitroaniline, and *m*-nitro-*p*-toluidine. Another major item now manufactured is acetanilide. During World War II the Company was the largest manufacturer of this basic ingredient for sulfa drugs. It even converted certain equipment to manufacture sulfanilamide itself. For many years L. E. May was in charge of this department until his untimely death in Mar. 1946. Also during the war, Sherwin-Williams produced large quantities of dibutyl phthalate, enormous quantities of which were used for flashless gunpowder and as a plasticizer for lacquers.

Sherwin-Williams' first entry into the insecticide field came about very naturally. Walter H. Cottingham, who became general manager in 1898, foresaw that

the farmer producing more crops through control of insect pests would be able to keep his farm buildings and equipment well painted. The Company's distributing facilities enabled the marketing of insecticides at minimum expense, through its many paint and hardware dealers throughout the United States. The technically trained staff and factory facilities for dry-color manufacture could be readily converted to insecticides.

The paint pigment Paris green was the first item offered as an insecticide. It was so superior in quality that a large volume of business developed. However, it was also injurious to some crops. Research developed that lead arsenate was safer and in 1908 the Company undertook the manufacture of the basic type in paste form. Because of the great expense for glass packages and heavy shipping weight, dry lead arsenate of the acid type was developed in 1910 and has since been sold in ever-increasing quantities. The Company's first production of Bordeaux mixture was as paste in 1911, followed by a dry powder under the name of Fungi Bordo in 1914. Since that time many compounds of Fungi Bordo, arsenate of lead, and other arsenicals have been developed and marketed under proprietary names. Lime-sulfur solution was first produced in 1910, first in Chicago, and later at many other points so as to reduce shipping cost. E. C. Holton developed a dry form of lime sulfur in 1917 which was patented and continues to be sold in large volume. Production of calcium arsenate began at Chicago in 1916, and shortly after at the other plants.

As the sales for insecticides were developing all over the United States, it was felt desirable to establish a production center in the East. In 1919 the Frank Hemingway Co. of Bound Brook, N. J., manufacturers of insecticides since 1913, was acquired. In 1936 all manufacture of insecticides was consolidated at the very much enlarged Bound Brook plant under M. L. Sommerville, and production at Chicago was discontinued. The Company erected an insecticide plant at Oakland, Calif., in 1921, to handle the greatly increased Pacific Coast and Western demands.

The federal regulation against arsenic, lead, and other residues left on fruits and vegetables brought about the use of rotenone as an insecticide and the Sherwin-Williams Co. began to manufacture Roto-Dust in 1934. A year earlier it studied the use of copper sulfate as a fungicide and as a result, was the first to produce tribasic copper sulfate, now made under the name of Basi-Cop. The Company manufactures large quantities of DDT (Pestroy); the weed killer, butyl 2,4-dichlorophenoxyacetate (Weed-No-More); a scientific blend of insecticides and fungicides including DDT, rotenone, and other proven materials (Bug Blaster); and a very recent addition, hexaethyl tetraphosphate (Killex 100), for the control of red spiders and mites.

Much research—both in the Company's laboratories and in foundations at colleges—is being devoted to the development of new products. Specialization in fruit and vegetable growing has brought up new problems, and trained entomologists and plant pathologists are conducting research in the field and presenting the Company's products to the grower. The marketing of insecticides is under the management of A. J. Gunderson. The insecticides business has grown until the Company now handles a larger volume than any other company in the United States.

To control more definitely the quality of paint ingredients, the Company entered into the manufacture of linseed oil, white lead, leaded zinc, lithopone, and synthetic resins, under the general management of George A. Martin, then manager of auxiliaries, who in 1922 became president. The present manufacture of white pigments and linseed oil is managed by S. B. Coolidge.

Manufacture of lead carbonate was undertaken in 1910 by the Old Dutch

process. In 1920 a Quick-Process plant was erected and has now entirely displaced the slow Old Dutch process. Also, a plant for the manufacture of red lead and litharge was added. As the exterior house paint made by the Company used large tonnages of leaded zinc, it was decided to enter into its manufacture. In 1904 the G & G Zinc Oxide Co. of Joplin, Mo., was bought and later moved to Coffeyville, Kans., near an advantageous supply of natural gas, reorganizing in 1906 as the Ozark Mining & Smelting Co. Sherwin-Williams established a lithopone plant in Chicago in 1917 and erected a new plant at Coffeyville in 1931.

The Company has devoted much attention to the manufacture and treatment of linseed oil. In 1902 a plant to crush flaxseed was erected in Cleveland, equipped with hydraulic presses and later, with screw presses. Many refined and treated oils are also produced. About 10 years ago, when tung oil became so difficult to procure because of the Chinese-Japanese troubles, Sherwin-Williams Co. was in the forefront dehydrating castor oil, which has greatly reduced the consumption of tung oil in varnishes and enamels. A solvent-extraction plant for linseed, castor, and soybean oils is being erected.

The development of synthetic resins began in 1928 at Cleveland. Having outgrown facilities by 1933, the production of synthetic resins was added at Chicago. Construction of other plants is under way at Oakland, Detroit, and Newark. The Company now manufactures a wide variety of alkyd and phenolic resins and varnishes, whose development was supervised by Dr. J. V. Hunn until very recently, when he transferred to research in oils and was succeeded by J. A. Arvin. Sales manager of dry colors, intermediates, pigments, and resins is B. M. Van Cleve, with offices in New York, and branches in Cleveland, Chicago, and San Francisco.

Shortly after World War I, the Company undertook the manufacture of nitrocellulose lacquers. A superior product, Opex, was developed in 1922, which found much favor for automobiles, furniture, aircraft, and many metal products. In 1926 a complete plant devoted exclusively to lacquers was erected at Chicago; production of lacquer materials was also undertaken at other plants. Dr. N. E. Van Stone was the active superintendent of this department for many years, later succeeded by F. H. Lang, present superintendent. A wide variety of lacquers—both clear and pigmented, also undercoaters and reducers, represent a very large proportion of the protective and decorative coatings sold by the Sherwin-Williams Co.

The Company attained its leading position in the paint and chemical industry through continuity of sound business management. Henry A. Sherwin, starting in 1866, was president and general manager until 1898, when he appointed Walter H. Cottingham as general manager after his successful management of the Company's Canadian business. In 1909 Sherwin retired as chairman of the board and Cottingham was appointed president. Under his administration, and until he retired to become chairman in 1922, the business had grown 25-fold. This great expansion included acquisition of Lewis Berger & Sons, Ltd., of London, the establishment of manufacturing branches in Australia and New Zealand, and offices and warehouses in many other cities. Also during that period, the Detroit White Lead Works and Martin-Senour Co. of Chicago were brought into the organization.

George A. Martin succeeded as president in 1922 after wide experience as manager of the several factories producing white lead, leaded zinc, linseed oil, etc. He greatly expanded the manufacturing facilities and was much interested in the establishment of plants in Havana, Buenos Aires, and Sao Paulo, Brazil. He added the businesses of Acme White Lead & Color Works of Detroit, Lowe Brothers Co. of Dayton, John Lucas & Co. of Philadelphia, and W. W. Lawrence Co. of Pittsburgh. Martin was a great leader and brought into the organization many

men who are now top executives. During his administration, up to the time he retired as chairman of the board in Dec. 1940, the business trebled. He was succeeded as president by Arthur W. Steudel, who had grown up in the ranks and directed the sales of dyes, intermediates, dry colors, and chemicals.

Under Steudel the distributing facilities of the Company had been greatly extended and now embrace 42 warehouses, over 390 branches in leading cities all over the United States, and over 150,000 retail outlets. Also, many new products have been introduced, including a complete line of household polishes and waxes, DDT-insect repellent, 2,4-D weed killer, and Bug Blaster. The business has increased over 50% since Dec. 1940, until it now approaches 500 times the volume of the first year. During 1941-45 the Company supplied enormous quantities of paints, varnishes, lacquers, and chemicals for military use. It also managed a shell-loading plant for the War Department.

This continuity of good management had guided a staff of long experience and at the close of 1946 there were over 13,000 employees of whom 1,020 had completed 25 years in the Company's service. Since the beginning of the business, 1,588 have served for 25 years or longer and 55 completed 50 years.

The present officers of Sherwin-Williams are: A. W. Steudel, president; H. D. Whittlesey, senior vice-president; M. J. Fortier, vice-president and general manager; S. B. Coolidge, vice-president and director of auxiliaries; C. M. Lemperly, vice-president and director of sales; L. H. Schroeder, vice-president and treasurer; N. E. Van Stone, vice-president and executive general manager of institutional special products; T. G. Murphey, secretary. The directors comprise Fortier, C. P. Jarden (retired), Lemperly, Schroeder, Steudel, Whittlesey, and L. W. Wolcott (retired) of Sherwin-Williams; A. D. Baldwin of Garfield, Baldwin, Jamison, Hope & Ulrich; C. S. Eaton, Otis & Co.; George Gund, president, Cleveland Trust Co.; D. A. Kohr, president, Lowe Bros.; G. H. Robertson, vice-president and general manager, Acme White Lead & Color Works; Thos. E. Wilson, Wilson & Co.

FOSTER D. SNELL, INC.'s present head, Foster Dee Snell, began consulting work while still a graduate student at Columbia University and an instructor in chemistry at the College of the City of New York. The first laboratory, however, was set up at Pratt Institute, Brooklyn, N. Y., where Dr. Snell began teaching industrial chemistry in 1923, immediately after receiving his Ph.D. from Columbia. Next year the laboratory hired its first full-time assistant. Just after getting her M.S. in chemistry, the consultant's wife, Cornelia Tyler Snell, served as an assistant, 1925-26, before continuing her graduate studies. In 1926 Cyril S. Kimball joined the Company, then a proprietorship, as an assistant.

Business came in during this period from a number of industrial plants in New Jersey which were struggling to conform to a new state law requiring treatment of trade waste before its discharge into rivers and streams. Detergents were then an important field of investigation for this group and have continued, from the early study of alkaline salts as soap builders to current studies of synthetic detergents and other surface-active agents.

The consulting work grew so rapidly that in 1927 a separate laboratory was opened at 35 Myrtle Ave., Brooklyn. Next year Dr. Snell resigned from Pratt Institute and opened an office at 130 Clinton St., Brooklyn. By 1929 the laboratory occupied two floors and had a staff of 25. At the end of 1930 the Company was incorporated in New York under the name of Foster D. Snell, Inc. The first directors were Foster D. Snell, president; Beatrice Fox, secretary-treasurer; Cyril S. Kimball, Ray Hedman, and Franklin Bivins. Financing was by issue of com-

mon and preferred stock subscribed by employees; the preferred stock was later retired.

A small manufacturing organization, the Hull Co., was started in 1932 for the benefit of certain clients. It is still in operation as a division of Foster D. Snell Research, Inc., a wholly owned subsidiary organized in 1946 and incorporated in New York. In 1931 a partially owned subsidiary, Foster D. Snell Sales Corp., was organized to serve as a sales outlet for clients, with a New York office at 307 Fifth Ave. This was only moderately successtul and was dissolved in 1933. Dr. Snell became president and director of Chemsearch, Inc., a partially owned subsidiary in 1938.

The Snell, Inc., offices and laboratory were moved in 1933 to space on two floors of the former Brooklyn Eagle Bldg. at 305 Washington St., Brooklyn. Steady growth of the Company occurred from this point on; the personnel numbered about 50 at the beginning of World War II and 80 at the end. Two members of the present executive committee joined the staff during this period of expansion, Leonard C. Cartwright in 1936, and Albert F. Guiteras in 1940. In 1942, in order to obtain further capitalization, an issue of debentures was made to employees only. The volume of business has steadily grown from a few dollars a year in 1920 to that now approaching seven figures.

The success of the Company has been derived primarily from a delegation of responsibility. Serving as account executives at the present time, in addition to Snell, Kimball, Cartwright, and Guiteras, are J. Mitchell Fain, Daniel Schoenholz, John Mahoney, and Chester A. Snell. Another factor contributing to success has been the application of experience in one field to another, noncompetitive one. As an illustration, in the late 1920's, the results gained on alkaline salts as soap builders were applied in development of hair-waving preparations for another client, and a few years later to stabilization of gloss-drying waxes for a third.

All research has been carefully planned and closely supervised, with analytical work a definitely subordinate activity. New departments have been added from time to time: bacteriology in 1936, toxicology and clinical work in 1940, vitamin research in 1941, rubber and plastics in 1942, and market research in 1946. Chemical engineering had gradually developed into a separate department for process development, and design and construction of new plants.

At the end of 1945 the Company bought a 10-story fireproof building at 29 W. 15th St., N. Y. City, and late in 1946 began extensive alterations and conversions for offices and laboratories. The present board of directors consists of Foster D. Snell, president; Cyril S. Kimball, secretary-treasurer; and Ray Hedman, comptroller. The executive committee is composed of the three directors plus Leonard C. Cartwright and Albert F. Guiteras. Dr. Snell is also a director of Cargille Scientific, Inc., and of Johnson Consumer Industries, Inc., a subsidiary of Bowser, Inc.

The Company has encouraged the patenting of developments on behalf of clients. Nearly 100 patents have been granted to members of the staff, who are urged to publish scientific articles, and a number of whom have held office in scientific societies. As a means of maintaining contact with clients, a house organ, the *Chemical Digest* was started in 1931, summarizing new developments in chemical and allied fields, important articles on research, and popular scientific subjects.

SOLVAY PROCESS COMPANY was formed in 1881, became a wholly owned subsidiary of Allied Chemical & Dye Corp. in 1920, and a division in 1948. It has three plants for the manufacture of alkalies, at Syracuse, N. Y., Detroit, and Baton Rouge, La., and two plants for the manufacture of nitrogen products, at

Hopewell, Va., and South Point, O. It was the pioneer producer of alkalies in the United States, introduced the by-product coke oven in this country, and, with its subsidiaries and affiliates, was the first domestic producer of synthetic ammonia.

The original purpose was to manufacture soda ash by the ammonia-soda process near Syracuse. Prior to the development of this process, the manufacture of soda ash had presented many difficulties; despite numerous attempts, none had been manufactured in this country. Syracuse was selected because of its proximity to large deposits of limestone and salt brine springs, and abundant water from nearby Onondaga Lake.

The first soda ash was produced at Syracuse in Jan. 1884. Initial capacity of the plant was small and many difficulties were encountered. However, the Company doubled its soda ash capacity during the period 1885-87, began the manufacture of bicarbonate of soda in 1888, and added caustic soda in 1889. Domestic production of such fundamental products fostered other American industries on a broad front. The Company continued this role as it added further products, established new plants, and expanded its capacities. At the same time, it continued to improve operations and reduce costs. Typical was the cable-and-bucket line, established in 1889, to carry limestone from the Company's quarry to the Syracuse plant, an advance of considerable significance in its day.

Two important technical problems in the early days were the weakness of the salt brine from the local springs and the limited supply of ammonia. Work done to solve the first of these problems led to the discovery of hitherto unknown natural resources within the area, while solution of the second founded a new national industry which has become vital to our national welfare.

The brine from which salt was being made at Syracuse being too weak for satisfactory soda ash production, solid salt brought from some distance in canal boats, had to be added. Solvay was convinced that in the neighborhood were substantial deposits of rock salt. Explorations were carried out, test wells sunk, and eventually the Company's present deposits near Tully, N. Y., 18 miles from the Syracuse plant, located. Operating wells were drilled and the long pipe line from Tully was constructed in 1889.

Originally, Solvay's only source of ammonia were the gasworks of central New York cities. The ammonia-recovery operations of these works were inadequate and inefficient and the Company's ammonia supply uncertain annd expensive. While substantial effort was made to induce the gasworks to increase their ammonia output by improved recovery, even complete success in this regard did not promise sufficient ammonia to meet the requirements of alkali production if it continued to increase as Solvay believed it would. Consequently, in 1892, the Company constructed a by-product coke-oven plant at Syracuse. This plant consisted of only 12 ovens, tiny by present standards. However, it was the first by-product coke plant on the American Continent and continued to be the only one for nearly four years. In 1895 Solvay sponsored the organization of Semet-Solvay Co., established to construct and operate by-product coke plants. Thus was laid the foundation for the vast coke by-product and coal-tar chemical industry.

The capacity of Solvay's original soda ash plant was quadrupled in the first decade. Towards the end of this early period, in 1890, Solvay introduced dense soda ash which soon became popular with the glass manufacturers. It was originally made by heating light ash in furnaces to its fusion temperature (1,564° F.). In 1904 a low-temperature (monohydrate) process, producing a better-graded and less dusty product, was substituted. The process was again improved in the early 1920's to make a practically dustless product which could be graded within narrow limits in a wide range from the finest particles to coarse-grained. Also in the

early 1920's, Solvay developed and offered extra-light soda ash, which is of value principally in detergent mixtures.

By-products began to receive attention and 1894 marked the first production of sodium sesquicarbonate, sold under the name of Solvay Snowflake crystals. This product has become an important detergent. In 1895 precipitated hydrated calcium sulfate was developed as a filler for writing and specialty papers and sold under the name of Crown filler. Calcium chloride was first produced at Syracuse in 1897.

Better to serve the rapidly growing demand for alkalies in the West and Middle West, Solvay commenced construction of a plant at Detroit in 1895, which came into production in June 1897. Brine was obtained from wells drilled in the immediate vicinity; limestone was brought from a quarry several miles away which Solvay later bought; coke and ammonia came from the adjacent Semet-Solvay plant. The Detroit soda ash facilities were enlarged and caustic soda facilities were added in 1915.

In 1916 Solvay collaborated with Pacific Coast Borax Co. in the production of potash at Searles Lake, Calif. In the same year Solvay acquired property at Salduro, Utah, and installed facilities to recover potash salts by solar evaporation from local natural deposits. This venture into a new field was due to the urgent need for potash fertilizers during the First World War. Operations at both Searles Lake and Salduro began in 1917 and were discontinued shortly ofter the end of the war.

Desiring to expand the uses for its by-product ammonia, Semet-Solvay Co., soon after World War I, erected small-scale ammonium chloride, ammonium bicarbonate, and sodium nitrate exploratory plants adjacent to the soda ash plants at Syracuse. These pilot plants were taken over by Solvay in 1926 and developed into sizable commercial operations. Manufacture of liquid chlorine by electrolysis of sodium chloride was undertaken in 1927 at Syracuse. A year later, potassium chloride was partially substituted for the salt, enabling production of caustic potash along with chlorine. This also made possible production of potassium carbonate, which was added later.

In 1929 facilities for production of caustic soda at Syracuse and soda ash at Detroit were expanded. The Detroit soda ash plant was again expanded in 1930. That same year witnessed a major expansion of the soda ash producing capacity at Syracuse, which necessitated an enlargement of the boiler plant. This furnished an opportunity to install more high-pressure steam boilers, the first of which, installed in 1927, are believed to be among the earliest in the country.

A new alkali plant at Baton Rouge was commenced in 1934, to produce both ash and caustic, and the same year the Syracuse chlorine plant was enlarged, while in 1937 a new electrolytic chlorine plant was built at Baton Rouge. In 1935 a plant was constructed at Hopewell to produce chlorine directly from salt without simultaneously producing caustic soda. The new process developed by the Company's Research Department proved successful and in 1941 work was started to double plant capacity.

Construction was started in 1941 on a synthetic phenol plant at Syracuse, and on additional soda ash capacity at Baton Rouge. In 1942 Solvay commenced construction of a plant at Kings Mountain, N. C., for spodumene concentrates, a raw material used in the manufacture of various lithium products essential to the war effort. The plant was completed and went into production during the first half of 1943.

Prior to 1914 the United States, as well as the rest of the world, was dependent on Chile for nitrate of soda and on Europe for most of its by-product ammonia, which was imported as ammonium sulfate. However, ammonia synthesis had be-

come a subject of study in laboratories throughout the world, among them the Laurel Hill laboratory of General Chemical Co., now a division of Allied Chemical. By 1917 General Chemical had made substantial advances in the art, which led to plans for the construction of a small commercial unit at Shadyside, N. J. With the imminence of the United States' entry into World War I, General Chemical at the request of the War Department turned its process over to the Government without charge, also making available its plans, the equipment, and materials it had already procured or ordered, and its entire personnel concerned with the process. The Shadyside project thus became the embryo of the U. S. Nitrate Plant No. 1 at Sheffield, Ala., which in Sept. 1918 produced the first synthetic ammonia manufactured in the country. The plant was shut down in Jan. 1919 before the operating difficulties and process flaws inherent in new operations had been eliminated.

Meanwhile, Solvay and Semet-Solvay had been developing the possibilities of synthetic ammonia. About a year after the end of World War I, they joined with General Chemical for the commercial development of General Chemical's process, forming Atmospheric Nitrogen Corp. to carry out the undertaking. Construction of a plant was begun at Syracuse, which went into run on Aug. 8, 1921, America's first successful commercial synthetic ammonia plant. The Syracuse plant was operated for a number of years as an experimental unit to explore markets and develop technical information and operating experience. Based on data so obtained, a much larger plant was begun at Hopewell in 1927. This site was chosen because of its tidewater location, permitting water shipments to the fertilizer ports of the South Atlantic and Gulf Coasts; its geographic position midway between the agricultural markets of the South and the industrial markets of the North; its direct accessibility by rail to coal and coke supplies in West Virginia and the Ohio Valley; and a year-round temperate climate favoring industrial operations. This plant was substantially expanded in 1930 and again at the beginning of World War II. Solvay took over operation of the Hopewell plant in 1934.

In 1926, during the design period for the Hopewell plant, laboratory studies at Syracuse developed a process for manufacture of sodium nitrate from soda ash and the oxidation products of ammonia, and sodium nitrate was shipped from the first full-scale commercial unit at Hopewell late in 1928, about two years after laboratory work had been started.

Shortly after Hopewell began operations, synthetic anhydrous ammonia and ammonia liquor became important sources of nitrogen in mixed fertilizer. Ammonia was employed for neutralizing residual acid of superphosphate, simultaneously adding nitrogen to the mix. To facilitate the addition of more plant-food nitrogen to fertilizers, a number of solutions were developed. These solutions, consisting first of sodium nitrate in ammonia and then of ammonium nitrate in ammonia, add large quantities of nitrogen to mixed fertilizer but comparatively limited quantities of free ammonia for neutralizing. Their use utilizes ammonia at comparatively low vapor pressure and makes the handling of ammonium nitrate a simple operation of flow of liquid through pipes rather than the more costly movement of solids. The techniques developed in handling these solutions were later to prove of great value in shipping ammonium nitrate from nitrogen plant to explosives plant during World War II.

After Pearl Harbor and before completion of U. S.-owned ammonia plants, production of nitrogen products at Hopewell was of prime importance. In addition, at the request of the Army Ordnance Department, Solvay undertook early in 1941 the construction and operation of an anhydrous ammonia plant for the Government at Henderson, Ky., and later another ammonia plant at South Point, O. To

these plants the Company loaned a large number of trained and experienced employees from its Hopewell plant and contributed inventions, secret processes, technical information, and know-how free of royalty.

In May 1943 a new plant at Hopewell for the manufacture of ammonium nitrate-limestone, a fertilizer compound, was completed and went into production. The Hopewell plant also produced other new products during the war, including high-purity nitric acid, nitrogen tetroxide, and nitrosyl chloride; solid ammonium nitrate for explosives; and water solutions of sodium nitrite and nitrate for detinning scrap tin plate and salvaging tin cans. In 1946 Solvay purchased the South Point plant from the Government.

E. R. SQUIBB & SONS began more than three-quarters of a century ago when Dr. Edward Robinson Squibb opened a small manufacturing laboratory on the waterfront of Brooklyn, N. Y. There was then great need for reliable drugs and medicines of standard quality and tested potency. It was a time when drugs were bought from the lowest bidder like the commonest commodities, when the buyer took his chances with what he bought, when standards of purity, quality, and even veracity were questionable. Dr. Squibb helped to revolutionize the development, the manufacture, and the standardization of medicinal preparations.

Young Squibb dreamed of becoming a physician, and to make this possible he served five years as an apothecary's apprentice. Out of his meager pay he saved enough to enter Jefferson Medical College, where he graduated with high honors in 1845. With the outbreak of the Mexican War, Dr. Squibb became an assistant surgeon in the Navy. Naval officials soon began receiving numerous reports from this minor medical officer agitating for drug reforms—standardization and purity of raw materials and accuracy of prescriptions. Finally in 1852 Congress appropriated limited funds to establish a naval laboratory for drug research. In a small room in the Brooklyn Naval Hospital, Dr. Squibb went to work with equipment of his own design and construction. His research was only one of the number of duties, which included serving as physician and surgeon in the hospital.

Because of the urgent need for anesthetics, he first concentrated on them. The mere demonstration of the anesthetic value of ether in 1846 did not automatically make the boon available to everyone. On the contrary, the early ether contained toxic impurities and was highly variable in potency. The fault lay partly in the method of manufacture. Dr. Squibb made the crucial improvements in the production of ether which made it possible, for the first time, to produce pure anesthetic ether of consistent strength. It was a work which occupied years, and required the building of at least 20 stills. Unwilling to make personal capital out of the new process, he published a full account in the *American Journal of Pharmacy,* Sept. 1856. Squibb ether became and remained the standard of the world, and is today made by virtually the same process which Dr. Squibb perfected in 1852.

Squibb's next important project was to develop anesthetic chloroform of standard quality and strength, and when he had accomplished this he went on to make a stabilized solution of cocaine. Meanwhile, he was busy testing, assaying, and standardizing a wide variety of drugs used by the Navy. Since there were no prior standards of purity and efficacy, Dr. Squibb established his own, devising methods of assaying crude drugs and developing processes for manufacturing pure drugs from raw materials. Many of his improvements and specifications survive unchanged today.

As important as his discoveries was the impact of Squibb's working philosophy on medicine and pharmacy. "Look at the bottle, look at the label, look before you fill, look when you have filled," was his rule. He personally signed the labels

on all products which he had made or tested, and this signature soon became famous in the Navy. Many doctors refused to accept medicines without the Squibb label, and thus Squibb products became the criteria for the drug industry.

Still Congress refused to vote more than niggardly appropriations for the naval research laboratory. However, in 1857 the chief medical purveyor of the U. S. Army made an encouraging proposal. The Army had been trying to create a reliable source of supply for drugs and anesthetics, but had not succeeded in getting an appropriation. If Squibb would establish his own laboratories, explained the chief medical purveyor, the Army would buy the bulk of his output. Squibb had no difficulty in raising capital, mostly among professional friends in Brooklyn, and late in the summer of 1858 he commenced equipping the laboratories of "Edward R. Squibb, M.D." in a small brick building near his home. On Christmas Eve of that year a bottle of ether tipped over by a careless assistant spilled near an open flame. In minutes fire spread through the laboratory. Squibb's first and only thought was of the records of formulas, tests, and experimental data which represented his life's work. Disregarding his own safety, he rescued an armful of notebooks. By the time he reached the street most of his clothing had burned away, and his hands and face were horribly seared, one hand injured so badly that it later had to be amputated. As he lay at home, slowly recuperating, a group of distinguished doctors and surgeons banded together and subscribed nearly $2,100 to help re-establish his laboratory. By the end of 1859 the laboratory was again in operation, and at the outbreak of the Civil War, it was in a position to meet many of the needs of the Union Armies.

As business expanded, Squibb maintained his rigid adherence to the standards he had created. He worked on the 1860 revision of the Pharmacopoeia and battled to establish improved U.S.P. standards for drugs. In 1879 he proposed a drastic Pure Food & Drugs Act (also covering cosmetics) which served as a model for a number of state laws prior to the first federal legislation in 1906. During the closing years of his life, management fell largely to his sons, and in 1895 the firm became known as E. R. Squibb & Sons. For five years after the death of Dr. Squibb the Company maintained the *status quo*. Manufacture and distribution were an a small scale and consequently Squibb products were not widely available. In 1905 the Squibb family realized that both new capital and new management were needed.

Lowell M. Palmer and Theodore Weicker, who purchased the Squibb Co., were responsible for its transition from a one-man enterprise to a big business. Both were thoroughly familiar with Dr. Squibb's principles and methods, and were determined to maintain them. "Product control" is the guarantee that every product has passed the most rigid inspections at every point in manufacture from raw materials to packaging; that it is correctly labeled; that it represents the best and most efficacious preparation available for the purpose. A number printed on the label of every container which leaves the factory is but the outward sign of such vigilant Squibb control. Under the present management—Carleton H. Palmer, chairman of the board, and Lowell P. Weicker, president, sons of Lowell M. Palmer and Theodore Weicker—the basic function of the house has remained the same as under Dr. Squibb.

The first laboratories occupied one small building with fewer than 100 employees. In 1900 the yearly sales were in terms of thousands of dollars, and Squibb products numbered only about 80. Today the plant has 15 buildings comprising the Company's Brooklyn laboratories where most of the manufacturing of pharmaceuticals and chemicals is done. A few years after E. R. Squibb & Sons was incorporated in 1905, land was purchased at New Brunswick, N. J., for an ether

plant. Shortly thereafter, the Squibb Biological Laboratories were established at this location, and in 1915, Dr. John F. Anderson, then head of the Hygienic Laboratory, U. S. Public Health Service, became their director. Today the New Brunswick plant occupies approximately 87 acres, housing in addition to the biological and virus laboratories, the penicillin plant and the new streptomycin plant. The Biological Laboratories have played a prominent part in the development and improvement of such biological products as tetanus toxoid, whooping cough and typhus vaccines, and numerous endocrine products, notably Amniotin. The production and standardization of Intocostrin from the valuable drug, curare, is an important achievement. The antibiotics penicillin and streptomycin are recent contributions.

Research work is centered at the Squibb Institute for Medical Research at New Brunswick. Opened in 1938, it has as its motivating policy the creation of a new virile source of fundamental scientific studies. The Institute has, within nine years, achieved worthy distinction, A few of its contributions include separation and purification of the gonadal principles of the anterior pituitary gland; isolation in crystalline form of sodium penicillin and aspergillic acid; synthesis of sulfathiazole; and recognition of 2-methyl-1,4-naphthoquinone as a compound of exceedingly high vitamin K activity. Extensive studies of promising significance have been made of measles and malaria. The findings of the Squibb Institute are shared with many other research groups. A good proportion of research projects is carried out in collaboration with outside workers.

The executive and sales offices of the Company are located in the 34-story Squibb Bldg. on Fifth Ave., N. Y. City. Squibb subsidiaries and branches are operating in Canada, Mexico, Cuba, Brazil, Argentina, Uruguay, Colombia, Venezuela, Peru, Philippines, and Puerto Rico. The warehousing, packing, and shipping activities of the export companies are housed in a large building recently purchased in Long Island City. Providing a working surface of approximately 437,000 sq. ft., this building also houses the main branch of the Squibb Library, the extensive accounting and statistical departments, and other activities.

The annual volume of sales now runs around $60,000,000. Employees number some 6,300 and Squibb products about 400, a list which extends virtually to every important field in medicine, surgery, and dentistry.

Squibb products range from dental cream and simple home necessities to complex anesthetics, vitamin preparations, biologicals, glandular products, and chemotherapeutic agents such as penicillin and streptomycin. A few in which Squibb pioneered are: Intocostrin or curare, which it introduced to modern medicine. Squibb was the first large company to undertake the investigation of this complex drug, used for centuries by South American Indians in hunting because of its paralyzing effect on the muscles of the body. Work on curare was done by the Biological Laboratories, in collaboration with Dr. A. R. McIntyre of the University of Nebraska. Intocostrin's activity has been shown to be due almost entirely to the presence of a crystallizable alkaloid, *d*-tubocurarine chloride, which is also now available. Intracaine, a new anesthetic, was the result of many years' research by the Squibb Laboratories. Lygranum is used in the diagnosis of the venereal disease, lymphogranuloma venereum.

Squibb began to work with penicillin in 1940 and was able to isolate a variant strain of mold which produces substantially larger amounts of penicillin in surface culture. This was made freely available to other producers and helped make possible the volume production of penicillin so urgently required during the war. The first isolation of any form of penicillin was made by Squibb in June 1943 when penicillin G as the sodium salt was crystallized. This made possible for the

first time the determination of the empirical formula and the molecular weight of penicillin G sodium salt and provided a pure standard for assay. Squibb developed a deep fermentation method for producing penicillin and perfected its extraction and processing on a large scale.

During World War II Squibb was one of the largest single suppliers of medicinal products for the Army and Navy and was responsible for, or participated in, developing many important war specialties. One of these was the Syrette—a small collapsible tube fitted with a sterile hypodermic needle for the convenient administration of a drug in solution, generally one dose. Most widely used was the Syrette with morphine tartrate because it could be easily administered to a wounded man on the field of battle. Pioneering in the field of pneumonia prophylaxis, Squibb developed a vaccine which prevents the most common types of lobar pneumonia. It was the first biological house to make available an influenza virus vaccine prepared by the centrifugal method.

STANDARD OIL COMPANY (N.J.) is the holding company for the Esso Standard Oil Co., the Standard Oil Development Co., and a large number of other companies engaged in the various phases of the petroleum industry. For brevity, this entire group of affiliated companies is referred to as the Jersey Co.

Its chemical history began in 1919 when president Walter C. Teagle, recognizing that the petroleum industry was then woefully unscientific, engaged Frank A. Howard to form a Development Department. Teagle was actively assisted by Edgar M. Clark, later a vice-president, in a long campaign to take the processing of petroleum out of the realm of empiricism and bring it under control of chemical engineers. It thus became inevitable that the Company should also, eventually, deploy in the field of pure chemistry.

Howard's original staff included Clarence I. Robinson, in charge of chemical research, and Nathaniel E. Loomis, in charge of process experimental work. The assistance of Warren K. Lewis of M.I.T., Ira Remsen of Johns Hopkins, and Robert A. Millikan of Chicago was secured in recruiting further staff, and Lewis's service as consultant has continued ever since.

In 1922 the Standard Development Co. was formed, under Howard, to handle the patent interests of the Jersey Co. separately from the research work. In 1927 the Standard Oil Development Co. was formed, under Clark, to engage in development activities and to take over the patent work of the Standard Development Co. In 1933 Howard assumed the presidency, with Robert T. Haslam as vice-president. Their successors in 1944 were, respectively, Robert P. Russell and Eger V. Murphree, until July 1947 when Russell resigned to become technical consultant to the International Basic Economy Corp., and Murphree succeeded him as president.

Following the 1927 reorganization of the Development Co., which was accompanied by a considerable expansion of the Esso Laboratories at Bayway, N. J., and the construction of new laboratories at Baton Rouge, La., the chemical activities of the operating affiliates of the Jersey Co. were also augmented. Many of these companies established independent technical organizations to conduct their own research and development work. They were all united, however, in support of the Standard Oil Development Co. under the terms of a "mutual plan" by which the Development Co. carried out projects for them jointly.

At present (1947) the Standard Oil Development Co., including the Esso Laboratories at Baton Rouge, has on its staff 752 professional employees holding degrees; the total in all the technical organizations of the Jersey Co. affiliates is

about 2,500. Chemical projects account for a large percentage of the research budget of the Development Co. and the technical budgets of operating affiliates.

The synthetic alcohol development, the first strictly chemical activity, began in 1916, when Carleton Ellis discovered a method of making alcohol from light petroleum naphtha. The object was to make isopropyl alcohol for conversion to acetone which was so badly needed in World War I. The Melco Chemical Co., with Matthew D. Mann, Jr., in charge, erected a pilot plant at Bayonne to develop this process. Two years later Melco originated the practical method of manufacturing isopropyl alcohol from cracked refinery gases by absorption of the olefins in sulfuric acid in the presence of gas oil to form acid sulfates, followed by hydrolysis. When the Melco unit showed promise of success, Clark and Robinson investigated, and in 1919 acquired the process and its manager for Jersey. Howard was instrumental in these negotiations and began his connection with the Company at that time. The process was installed at Bayway and, during a 10-year period, was improved and carried to full-scale commercial importance.

Bayway's initial isopropyl alcohol brought as high as $6.50 per gallon, whereas the present price is in the neighborhood of 30¢. In 1924, and again in 1929-30, the plant was expanded. At an early stage, in addition to isopropyl alcohol, sec.-amyl and sec.-butyl alcohols were manufactured to satisfy a demand for lacquer solvents. The business continued to grow and in 1932 the Standard Alcohol Co. was formed. National Distillers Products Corp. and others secured participation in this company through contribution of patent and process rights, but subsequently sold their interests to the Jersey Co.

Numerous additions have been made to alcohol facilities both at Bayway and Baton Rouge, so that today the Jersey Co. is turning out more than 50,000,000 gal. yearly of isopropyl, sec.-butyl, and ethyl alcohol, together with derivatives, including acetates and ketones. The alcohol company changed its name to the Enjay Co. in 1947 and, under the presidency of Harold W. Fisher, took over the marketing of all chemical products of the Jersey Co.

The use of hydrocarbon blends in gasoline originated in one of the steps in sec.-butyl alcohol synthesis: the removal of isobutylene from the feed stock. The isobutylene was absorbed in relatively dilute acid and then polymerized to diisobutylene. This was hydrogenated as early as 1927 to form isoöctane for use as a reference fuel. Full-scale commercial production of isoöctane came in 1929 when Jersey's alcohol plant made 1,000 gal. of diisobutylene for hydrogenation to isoöctane by the Ethyl Gasoline Corp. With the increased demand for high-octane blending agents, Jersey began to hydrogenate diisobutylene by its own process. Some of this isoöctane formed the first source of Jersey's superquality aviation gasoline blending agents and was used in the Southwest Air Races in 1935. When the war began in 1939, Jersey's hydrogenation plant at Baton Rouge was the largest single source of 100-octane gasoline in the world. Other polymerization processes, notably the hot-acid polymerization process and the phosphoric acid process of the Universal Oil Products Corp., soon supplanted this original cold-acid process.

Fostered by the tremendous wartime demand, the alkylation process, in conjunction with the isomerization process, soon outstripped polymerization. It was developed independently by several companies. Jersey affiliates played a leading role in evolving this most important alkylation process, and its first large-scale exploitation began in 1938 at the Baytown refinery of the Humble Oil & Refining Co. It was responsible for the major portion of the gasoline-blending agent requirements for aviation gasoline in the recent war. The present capacity of the process throughout the world amounts to 120,000 bbl. per day.

To augment the supply of isobutane for the alkylation process, it was necessary to convert a certain amount of n-butane to isobutane by isomerization. The Jersey process uses aluminum chloride absorbed on bauxite as the catalyst and anhydrous hydrogen chloride as catalyst promoter. It was employed during the war in 12 plants having a combined capacity of about 25,000 bbl. per day of isobutane, which is 40% of the total known isomerization capacity. Use of these processes increased the output of 100-octane aviation gasoline from an insignificant amount before the war to about 600,000 bbl. per day.

Before the advent of high-octane blending agents, came the anti-knock additive. In 1921 Thomas Midgley, Jr., of General Motors discovered the remarkable anti-knock properties of tetraethyl lead. At that time, however, the available method of making it was not applicable on a large scale because it was founded on the use of bromine, a comparatively rare element. After laboratory investigation, the Jersey Co., convinced that tetraethyl lead would have a far-reaching effect on the gasoline business, took immediate steps to develop a practical method of manufacture. Charles A. Kraus of Clark University, a leading authority on metallo-organic compounds, was retained to lead this research. A procedure using ethyl chloride and an amalgam of sodium and lead was worked out and a pilot plant was put into operation at Jersey's Bayway refinery. This is the only commercial method of making tetraethyl lead. The ethyl chloride was made at the outset from alcohol, by a du Pont process. In view of the success of the Jersey process, General Motors and Standard joined forces to form the Ethyl Gasoline Corp. in 1924. Du Pont was called in to manufacture the new product by the Jersey process and erected extensive facilities at Deepwater, N. J. As the demand grew, more buildings were constructed, and in 1937 a major expansion was undertaken. Baton Rouge was chosen for the new plant since Jersey had in the meantime developed a process for making ethyl chloride from ethylene which was, and continues to be, produced there by a special cracking process.

The present-day importance of tetraethyl lead is indicated by the fact that 60,000 tons of lead are now being allocated yearly for its manufacture in the United States. Only 3 cc. of the material is used per gallon of motor fuel, because originally considered the maximum needed to improve knock rating. The Surgeon General of the U. S. Public Health Service, after an extensive investigation, gave a clean bill of health to gasoline containing this amount of tetraethyl lead and, in default of tests upon higher concentrations, he recommended in June 1926 that this be the maximum. This decision has been unquestioned ever since, except during World War II when aviation gasoline was commonly leaded with as much as 5 cc. per gallon.

In 1927 the newly established laboratories at Baton Rouge were primarily concerned with the adaptation to petroleum of the German high-pressure hydrogenation process, whose purchase was then under negotiation. It was to help in this work that Professors Haslam and Russell of M.I.T. then joined the Standard Oil Development Co. The technique of hydrogenation, using very high temperatures and remarkable new catalysts which resisted impurities, first revealed to the oil industry the revolutionary possibilities of catalysts in many of its commercial processes. The earliest commercial application of hydrogenation in the petroleum industry was in the improvement of lubricating oil and kerosene. The most important, however, were the isoöctane and toluene developments.

It was observed that under destructive cracking conditions the hydrogenation process produced significant amounts of toluene. This was brought to the attention of the Army's Ordnance Department by Jersey and in 1933 samples of synthetic toluene were made and sent to the Picatinny Arsenal for testing. Research

thereafter centered on improving the quality and yield of toluene and aromatic gasoline. The resulting process, which radically modifies the structure of the naphtha hydrocarbons, was found highly effective for gasoline octane number improvement as well as for toluene manufacture.

For many years the method of increasing the octane number and volatility of gasolines was by simple thermal reforming. In an early catalytic reforming process it was possible to obtain higher yields of aromatics at 900-1,000° F. However, an undesirable side-reaction resulted in excessive coke. It was then discovered that coke could be greatly reduced by hydrogen without adversely affecting aromatics formation. Since the process was essentially one of dehydrogenation of naphthenes, the product gas contained as much as 40-70% hydrogen. This product gas was recirculated instead of extraneous hydrogen, and the present hydroforming process was complete. In operating for toluene manufacture, highly naphthenic feed stocks are selected for hydroforming, and sulfur dioxide extraction, acid treating, and fractionation are used to obtain the final product.

By 1939 the toluene process had been greatly improved, and in June 1940 the Ordnance Department ordered two 10,000-gal. tankcars of synthetic toluene which were shipped from Baton Rouge to du Pont for nitration, in Aug. 1940—the first commercial synthetic nitration-grade toluene from petroleum. By hydroforming, about 120,000,000 gal. per year of nitration-grade toluene were added to the 30,000,000 available in the United States from the coking industry. A single hydroforming unit at Baytown, Tex., produced in 1942 more than half of the country's toluene requirements for that critical year.

Pioneer work in lube additives was done by the Standard Oil Development Co., starting in 1928 with the pour depressant Paraflow. Patents dating back to 1921 had disclosed the use of metal soaps, coal-tar pitch extracts, or fatty acid amides, but none of these solved the problem of lowering the pour point of lubricating oil. The answer was finally provided in 1930 by Garland H. B. Davis of Standard Oil Development, who used small percentages of an oily condensate made in Germany by reacting naphthalene and chlorinated wax. The pour-depressant potency of this material was greatly augmented in the Jersey process which was then developed. Commercial production of Paraflow began in a large way at Standard's Bayonne refinery in 1930 by chlorinating wax and combining it under proper conditions with naphthalene in the presence of aluminum chloride catalyst. About 1% of the product in paraffinic oils lowers the pour point by as much as 50° F. Made generally available to the oil industry by Jersey in 1931, Paraflow output is sufficient to treat more than 200,000,000 gal. of lubricating oil per year.

In 1932 Standard Oil Development experimented with another German additive called Oppanol, which was plastic and oil-soluble. It was made by the polymerization of isobutylene and, properly prepared and blended, it increased the viscosity index of lubricating oil. The product was manufactured and marketed by Jersey as Vistanex, then improved, developed commercially, and sold in 1934 as Paratone. Another important product, Paratac, which increases the stringiness of a lubricant, grew out of this development.

Work starting at Standard Development in 1924 and culminating in patents issued in 1927, covered the use of soaps to minimize gummy and carbonaceous deposits on engine parts. This detergent additive was superseded when the first all-purpose heavy-duty oil additive, Paranox 56, containing barium and sulfur, was made generally available to the oil industry. Present consumption of this product exceeds 1,000,000 gal. per year. Antioxidants for motor oils were patented by Standard Oil Development starting in 1931. The prototype in this category which is most widely distributed at present is Paranox 105, a compound containing

barium, phosphorus, and sulfur. A special additive, Parapoid, containing chlorine and sulfur, was launched in 1940 for extreme-pressure gear oil and is being distributed at a rate of some 2,000,000 lb. per year.

Few of Jersey's technological projects have been more interesting than the development of synthetic rubber. The process employed polymerization and the starting material was predominantly butadiene. Rights to the process in its early stages were acquired by Jersey from the German owners in 1929, in connection with rights to the hydrogenation process.

Jersey's earliest experimentation with synthetic rubber had to do with production of butadiene. In 1931-32 an experimental plant was constructed at Baton Rouge, in which an electric-arc process was used to convert natural gas to acetylene as a possible future source of butadiene. The process was a success but too expensive for commercial use. In 1941 a gas-oil cracking plant, succeeding the one used to produce ethylene from propane, was started at Baton Rouge to produce olefins for alcohol and tetraethyl lead manufacture, and also butadiene, which was recovered by a cuprous salt extraction method. Meanwhile, production of butadiene by dehydrogenation of normal butenes had been progressing. By the middle of 1941 a highly effective catalyst had been developed and the new process was ready for large-scale commercial operation.

By the time the lack of natural rubber became menacing, the Jersey Co. was far enough advanced in the development of butadiene production from oil to engage immediately upon the design and construction of plants. On Feb. 12, 1942, Jersey reviewed, with representatives of the Government and of the oil industry, its latest process design of a commercial butadiene unit. The earliest projects included in the Jan. 1942 program of the Government's Rubber Reserve Co. incorporated this process and it was thereafter adopted by most of the industry. The butene dehydrogenation plant of the Jersey Co. at Baton Rouge started production in May 1943, and that of the Humble Oil & Refining Co. at Baytown, in August. Ultimately six plants installed this process, with combined annual capacity of 285,000 short tons or 45% of the total government butadiene program. In addition, the cuprous salt process for purifying butadiene was adopted in 11 plants, with a total capacity of 220,500 short tons per year. During 1945, 54% of all the butadiene produced in government-owned plants and 90% of that part produced from petroleum sources was made by one or both of the Jersey processes.

As for Buna rubber, it had progressed in Europe to the point where in 1938 the Germans had large commercial plants in operation and were shipping samples of a specialty Buna known as Perbunan to American rubber companies. In Sept. 1939, Jersey took over the American rights to the Buna process and prepared to manufacture Perbunan. By 1940 it was ready to license other rubber companies, and in January Jersey began to construct the first American Buna plant, enlarging it in Oct. 1941. This was a specialty plant to manufacture five tons of Perbunan per day from butadiene and acrylonitrile. It was here that the first large-scale Buna S (made from butadiene and styrene) production in this country began in Dec. 1941. The design and operating details of this plant were made available freely and served as the basis for the larger Buna S plants which were built and operated by the American rubber industry for the Government. By 1944 Buna S synthetic rubber construction program, utilizing butadiene both from alcohol and petroleum, had a production surpassing the normal peacetime consumption of rubber in the United States of approximately 600,000 long tons per year. Present production capacity for Buna S exceeds 1,000,000 long tons per year.

Butyl rubber is an American achievement. It grew out of work by William J. Sparks and Robert McKee Thomas, chemists of Standard Oil Development Co.,

who, under the direction of Per K. Frolich, were developing additives to improve lubricating oil. In their investigation of low-temperature reactions of polyisobutylenes, an entirely new type of catalyst and different solvents were tried. The molecular weight of the polyisobutylene was gradually increased to a point where it more and more resembled crude rubber. In the summer of 1937 a mixture of isobutylene and butadiene was polymerized to produce the first Butyl. This material could be vulcanized and had resilience, elasticity, and tensile strength to a degree comparable with natural rubber. It was subsequently improved by the substitution of isoprene for butadiene.

Unusually difficult engineering problems were overcome in developing a practical commercial process for Butyl because of the highly exothermic reaction and the very low temperature required. In June 1941, influenced by the growing threat to the nation's supply of natural rubber, Jersey Co. engineers were ready to build a practical full-scale Butyl plant, although pilot-plant work was incomplete. This unit was to be financed and constructed entirely by Jersey and $4,500,000 was appropriated for the purpose. In Feb. 1942 this plant at Baton Rouge was taken over by the Government and expanded to a yearly capacity of 33,000 tons. Another plant was built at Baytown, Tex., with a similar capacity, where commercial production began in Mar. 1943. During the war about 675,000 lb. of Butyl per month went into windproof and waterproof cloth, linings for tanks and pumps that handle acids, steam and fire hose, and conveyor belts for hot materials, and about 12,000,000 lb. per month were used for inner tubes. In 1946 domestic production was more than 80,000 tons.

In 1924 Herbert G. M. Fischer developed a new process for refining white oils at Jersey's Bayway refinery. In this process the oil-soluble sulfonates, which had been destroyed in the older refining techniques, were recovered by oxidation with fuming sulfuric acid. In the late 1930's, after years of experimentation, Jersey's chemists developed methods of segregating and purifying the sulfonates first used in cutting oils and as emulsifying agents, and now expanded to include textile oils, leather oils, rust preventives, wetting agents, and fat-splitting agents. Present U. S. output is more than 40,000,000 lb. annually in forms ranging from 25% dispersions in water as wetting agents to 70% solutions in oil as emulsifiers.

In 1934 the chemists of the Baytown refinery of the Humble Oil & Refining Co., a Jersey associate, developed a process for recovering naphthenic acids from the extracts produced in the caustic washing of naphthenic petroleum distillates. Uses for these unwanted acid by-products were eventually found in the manufacture of metallic naphthenates for paint driers, for mildewproofing, and for gear compounds in steel mills. Their recovery was later extended to all of the Jersey refineries handling naphthenic petroleum. The Standard Oil Development Co. contributed to the naphthenic acid purification techniques. At present the annual distribution by Jersey alone amounts to more than 20,000,000 lb. per year.

It can be seen that, starting 28 years ago with no chemical background but with a practically unlimited supply of chemical raw materials, the Standard Oil Co. (N.J.) has been drawn into a dozen important fields of chemical activity: alcohols, gasoline-blending agents, aromatics, lube additives, butadiene, rubber, sulfonates, naphthenic acids. Plastics, asphalt additives, detergents, and agricultural chemicals have been other fields of Jersey research whose products are now entering the commercial phase. A whole new area of hydrocarbon synthesis, starting with methane or coal, is being explored. Valuable chemicals are expected to issue, together with the liquid fuels sought.

STAUFFER CHEMICAL COMPANY had its start as a partnership in 1886, when San Francisco was a growing city of 250,000 people. Few manufacturing concerns existed and almost no chemical manufacturing. Eastern and European merchandise was bought and sold at high prices by merchants who opposed the establishment of local factories. California, the land of gold, grain, and cattle, was ready for its first industries.

In 1885 John Stauffer came to San Francisco as sales agent for European producers of heavy chemicals. He saw the need for local manufacture of many chemicals and determined to take advantage of the opportunity. In those days sailing vessels carrying grain from the Pacific Coast to England and Europe loaded cliffstone from the chalk cliffs of the English Channel as ballast for the return trip. Upon arriving in San Francisco the chalk was dumped in the bay prior to reloading grain. Stauffer erected a grinding plant in the North Beach district of the city, purchased two shiploads of cliffstone, and soon was offering an excellent quality of ground chalk or whiting at half the price of the imported material.

Within a few months he interested some European friends in his plans for producing chemicals in California, and in 1886 formed a partnership under the name of Stauffer & Co. The new company produced sal soda and within a few years was refining sulfur.

When John Stauffer entered the chemical business in San Francisco there were only three firms in the field. John Reynolds, proprietor of the California Chemical Works, had established his business in 1854 and by the 1880's was making sulfuric acid and sulfur products, and carrying a large line of imported chemicals. Judson and Shepard had established the San Francisco Chemical Works prior to 1865 and were refining sulfur, making sulfuric acid, and jobbing chemicals. Later, explosives became their principal line. During 1879, just prior to his graduation from the University of California, John H. Wheeler had become interested in carbon bisulfide, a product developed in France as a control for phylloxera, a root-destroying insect then a serious threat in vineyards. After graduating, he commenced importing carbon bisulfide, but at $1 per lb. the California growers could not afford it. He then undertook to manufacture this material and in 1880 was producing it at Berkeley for a fraction of the imported cost. Within a few years he enlarged his operation and began refining sulfur.

Thus there were four San Francisco firms in the sulfur business. Stauffer was selling Wheeler's carbon bisulfide, and in turn was furnishing him his crude sulfur, so the two had a unity of interest. Stauffer proposed the formation of a new sulfur company to be jointly owned by Reynolds, Shepard, Wheeler, and Stauffer and in 1894 this was accomplished by the incorporation of the San Francisco Sulphur Co., now wholly owned by the Stauffer Chemical Co. John Reynolds in the meantime began producing carbon bisulfide in San Francisco, and after several years it was agreed by the three parties to merge their operations into a single firm, Wheeler, Reynolds & Stauffer, which is still operating.

On July 26, 1895, as the final step in bringing together the various chemical interests in the area, the Stauffer Chemical Co. was incorporated, with a paid-in capital of $300,000. Christian de Guigne was president, John H. Wheeler, vice-president, and John Stauffer, secretary. De Guigne, a young man in the banking business in San Francisco, had helped John Stauffer from the first with cash, credits, and financial advice. Upon the incorporation of the Company, he converted his advances into capital stock and underwrote the purchase of the European interest in Stauffer & Co. These three men, de Guigne, Stauffer, and Wheeler owned and actively operated the business for over 40 years. Their abilities were singularly

complimentary: de Guigne in finance and administration, Stauffer in discovery, research, and production; Wheeler in administration and production. They have passed on to their sons and employees high standards and traditions of excellence in these fields. The ownership of the Company still rests in the families of the three founders.

The new company undertook the manufacture of sulfuric acid, salt cake, and muriatic, nitric, and boric acids. It was the first, and until 1924, the only producer of boric acid in the West. A second sulfuric acid plant was soon built at near-by Richmond across the bay from San Francisco, and adjacent to it a carbon bisulfide plant. The Company acquired control of the California Vigorite Powder Co., later sold to du Pont, and formed a salt company which used solar evaporation of the bay water, and a borax-mining company. In 1900 a plant was built at San Francisco to extract cream of tartar and tartaric acid from the wine lees and argols of the California wineries. A superphosphate plant was built at Richmond and the sulfur-subliming facilities enlarged. Mining pyrites for the acid plants was also undertaken.

The earthquake and fire of 1906 heavily damaged Stauffer's San Francisco plants and destroyed the head office and records. The next few years were spent in reconstruction and in building up cash reserves for further expansion. Another sulfur-refining plant was built and additional borax deposits acquired. Late in 1912 a carbon bisulfide plant was built at Chauncey, N. Y., which later made many other chemicals. In 1917 a sulfur plant was built at Freeport, Tex., and in 1918 a muriatic acid and calcium chloride plant at Vernon (Los Angeles).

Stauffer Chemical has grown steadily until today it, with its subsidiaries, operates over 30 plants in almost every section of the country. In addition it has substantial interests in other chemical companies. The head office remains in San Francisco although, since 1932, the general managers have made N. Y. City their headquarters. Sales offices are located at New York, San Francisco, Los Angeles, Chicago, Portland, Houston, Tex., and Orlando, Fla. A European office is maintained in Paris.

The chemicals produced by the Stauffer companies include refined and processed crude sulfur, sulfuric acid, carbon bisulfide, alum, superphosphate, sal soda, boric acid, copperas, sodium hydrosulfide, nitrate of potash, chlorine, caustic soda, carbon tetrachloride, silicon tetrachloride, titanium tetrachloride and trichloride, zirconium tetrachloride, aluminum chloride, sulfur chloride, anhydrous hydrogen chloride and fluoride, tartaric acid, cream of tartar, Rochelle salt, tartar emetic, sodium bichromate, salt cake, and a line of insecticides. Today the emphasis is still on heavy chemicals.

Plant laboratories have been established wherever needed to guarantee process control and insure uniformly high-quality products. In addition, the Company maintains modern research laboratories and has pioneered in such fields as rubbermakers' sulfur, certain chlorides of rare metals, and carbon bisulfide. It is constantly looking for better ways to make better products for American industry and agriculture.

Stauffer's present board of directors comprises: Andrew F. Burke, Christian de Guigne III, Christian de Dampierre, Vincent H. O'Donnell, Hans Stauffer, John Stauffer, Jr., and Rollo C. Wheeler. The principal offiers are: Christian de Guigne III, president; Hans Stauffer, vice-president and general manager; John Stauffer, Jr., vice-president and secretary; Rollo C. Wheeler and Ferd W. Wieder, vice-presidents; and Christian de Dampierre, treasurer.

Albert Walter, who retired in 1946, played a most important part in the development of the Company during his 40 years of active work. He became Eastern

branch manager in 1912, general manager and director in 1933, president in 1942, and finally chairman of the board. In 1946 Christian de Guigne III was elected president, a post his grandfather had held from 1895 until his death in 1942. Prior to this, de Guigne III was active for many years as an officer and director of the Company and of many of its associated companies.

Hans Stauffer, a nephew of John Stauffer, started working for the Company in 1919, in the San Francisco Sales Department. In 1927 he came East to work with Walter. As general manager since 1941, he has guided the Company through the critical wartime years. John Stauffer, Jr., the only son of the founder, started the Southern California Division in 1918 and as manager has been primarily responsible for its unusually rapid growth and development. He has served on the board of directors since 1929, and is director and officer of many of the associated companies.

Ferd W. Wieder's 28 years with the Company included experience as a chemist in the plants, in the Sales Department, and as San Francisco Division manager since 1933. Rollo C. Wheeler, a son of John H. Wheeler, has been actively interested in the Company for many years and since the death of his father in 1939, has participated in its management. He operated his own brokerage firm for 10 years, and was twice president of the San Francisco Curb Exchange. Christian de Dampierre, also a grandson of Christian de Guigne, Sr., has worked in both San Francisco and New York offices since 1937. During World War II he served as an officer in the French Army, in 1946 was made treasurer of the Company, and in 1948 a director.

Vincent H. O'Donnell, a San Francisco attorney, has been Company general counsel since 1928, a few years later becoming an officer and in 1946, a director. Andrew F. Burke an experienced attorney, has served as director since his election in 1942. Joseph A. Donohoe, Jr., director from 1933 to 1948, is a grandson of a founder of Donohoe, Kelly Banking Co. and is now its president. This bank gave the Stauffer Chemical Co. invaluable financial assistance throughout its years of growth.

STERLING DRUG INC., was started back in 1900 to manufacture a single packaged medicine for a market within horse-and-buggy delivery range of Wheeling, W. Va. That business occupied two rooms on the second floor of an old building, its two principals serving as office, sales and production staff. From that modest beginning it has grown in stature in terms of pharmaceutical preparations, packaged medicines, household and toilet articles, and bulk chemicals for industry. It operates 51 plants and more than 100 sales, service, and branch offices throughout the world and will move its headquarters about 1950 into a 43-story building in the heart of New York.

The men who started this small business had been high school friends: W. E. Weiss, graduate of the Philadelphia College of Pharmacy, who was clerk in a drugstore at Sisterville, W. Va., and A. H. Diebold of Canton, O. The former owned the formula for Neuralgine, and the two organized a partnership in Sisterville to manufacture and sell that product. Within a year, however, they were searching for more capital and succeeded in finding three persons who were willing to invest with them. On May 14, 1901, the business was incorporated under the name of the Neuralgyline Co., with a capital of $25,000.

Sales the first year were only $10,000. Upon reflection, Weiss and Diebold concluded that building sales volume around a single product would be extremely difficult; moreover, they recognized the hazards of a one-product drug business because time can outmode medicinal preparations and science can make them use-

less. Accordingly, they embarked on a policy of product diversification. The first step was the purchase for $22,000 of a controlling interest in the J. W. James Co., established in 1869 to manufacture a number of products including headache powder. In 1902 total sales were $60,000. Half a dozen other businesses were acquired. At the time, their products contributed to sales; but for the most part they have either disappeared or demand has gone down the hill of popularity with Neuralgine.

Diversification was not the only policy established in 1902. Advertising was embraced as a guiding principle, with the appropriation of $10,000 and five salesmen sent to cover Pennsylvania, Ohio, and neighboring states. Further, initial earnings were applied to the purchase of a new building, and in 1903, the first of a long line of dividends that remains unbroken was paid. Amounting to $2,895, this initial dividend represented payment of 6% on the outstanding stock, rather than all of the profits then available for distribution.

On June 30, 1906, President Theodore Roosevelt signed the first Pure Food & Drugs Act. The business that is now Sterling moved forward under these new controls of drug manufacture. Domestic sales increased and spread in an ever-widening circle of markets, until its principal products became known in several foreign countries. By 1914 foreign trade had so increased that a subsidiary was organized to handle it. In 1917 the old corporate name was dropped and the business became Sterling Products (Inc.). "Sterling," came from Sterling Remedy Co., an Illinois corporation organized in 1890 and widely known as the manufacturer of "Cascarets," whose common stock had been purchased in 1909.

When the United States entered World War I in 1917, the Alien Property Custodian seized properties owned in this country by enemy aliens. Shortly after the Armistice, he offered for sale at public auction the stock of the Bayer Co., Inc., of New York, which had been created by the German Bayer Co. to manufacture and sell aspirin, physicians' drugs, and dyestuffs. A great many American firms were deeply interested in acquiring American Bayer. Sterling was the successful bidder, offering $5,310,000. To Sterling's manufacturing facilities had now been added an impressive plant and laboratories at Rensselaer, N. Y. American Bayer was adapted to fit into the organization. Sterling continued the aspirin business under the Bayer cross trade-mark. Winthrop Chemical Co. (now known as Winthrop-Stearns, Inc.) was organized as a new subsidiary to manufacture and sell the physicians' drugs which had been acquired, while the dye business was sold.

Unlike the early products, most of the brands acquired by Sterling in later years have retained and indeed increased their popularity. In addition to Bayer aspirin, they included Phillips' Milk of Magnesia, manufactured since 1872; Dr. Caldwell's, developed in 1893 by one of America's first baby specialists; Chas. H. Fletcher Castoria, which dates back to 1868; Andrews Liver Salt, best known in the British Isles; Dr. Lyon's Tooth Powder, developed in 1866 by I. W. Lyon, D.D.S.; Ayer's Pectoral, after whose manufacturer the town of Ayer, Mass., was named; Energine, originally sold as a motor fuel for racing cars and for one of the first submarines ever built; Molle Shaving Cream, which started as a skin balm but was developed into one of the first brushless shaving creams through its accidental use for this purpose by an employee who needed a shave but had no soap. Also acquired were Mulsified Cocoanut Oil Shampoo, Glostora Hair Dressing, Z. B. T. Baby Powder, Kling Dental Plate Powder, Ironized Yeast, Haley's M-O, and Midol.

At the same time, the base of Sterling's service to the profession was broadened. Through Winthrop, it made available to the medical profession pharmaceuticals of merit including Atabrine, the earliest antimalarial of World War II; Demerol; the sulfa drugs which it was the first to introduce in the United States; as well as Creamalin, Luminal, Novocain, Pontocaine, Zephiran, and others. Additional me-

dicinal products, such as Alcaroid and Caroid and bile salts, came with the acquisition of the American Ferment Co.

Service to other professions developed. Winthrop's anesthetics Tutocain and Novocain were useful to dentistry; and, through two companies which form the basis of the present Cook-Waite Laboratories, Inc., other anesthetics and Carpule cartridges for administering them were made available to dentists. Some of Winthrop's products likewise found application in the veterinary field.

Little by little, Sterling entered upon the manufacture and distribution of bulk chemicals for industry. At first, it merely distributed vanillin, but gradually, certain products manufactured by Winthrop found industrial application. These included Roccal, a sanitizing agent; bulk vitamins and other nutritive factors; and fine chemicals of especial value to flour and cereal milling, baking, milk, food freezing, and animal feed industries.

To promote its foreign trade, Sterling founded as early as 1919 a Canadian subsidiary, and it now has subsidiaries in several foreign countries. In addition Sterling Products International, Inc., was organized to cultivate markets in both hemispheres, and the Sydney Ross Co., which has plants and offices throughout Latin America where it has done business for half a century, was acquired.

A new management headed by Edward S. Rogers as chairman and James Hill, Jr., former treasurer, as president, was installed Aug. 29, 1941. Thereupon, Sterling became the strongest competitor of I.G. Farben in the pharmaceutical markets of Latin America. It developed its own aspirin product, Mejoral, to compete with the German aspirin; and to achieve widespread distribution, Sterling International and Sydney Ross were given several million dollars for intensive merchandising and advertising. Sterling challenged on another front. Whereas its business in physicians' drugs had formerly been confined to the United States and Canada, primarily, it now established a wholly new business in physicians' drugs and organized Winthrop Products, Inc., to develop markets for them throughout the world, with especial emphasis on Latin America.

Beginning in 1940, Sterling's production of Atabrine was stepped up repeatedly in accordance with American needs. In 1942 royalty-free licenses were offered to other American manufacturers for the war-production of this antimalarial; in 1943, 11 other firms turned to Atabrine production. Whereas Winthrop had turned out 5,000,000 tablets annually during the peace years, representing the total American demand, in 1944 the United States produced 3½ billion tablets, of which Winthrop was responsible for about half. Winthrop also worked on more than 100 other antimalarial compounds, and its Aralen emerged as an improvement over Atabrine and quinine. It was one of the first to produce penicillin and its research laboratories and plants produced important drugs for the treatment of such tropical diseases as African sleeping sickness, kala-azar, filariasis, and schistosomiasis. Winthrop won four Army-Navy "E" awards; so did the Hilton-Davis Chemical Co., which became a Sterling division shortly before the war's end.

In 1942 the corporate name was changed to Sterling Drug Inc., and the organization was revamped through the absorption of 16 domestic subsidiaries and the creation of operating divisions. Further, the door to expansion was opened by the relationships which Sterling had during the war with other American manufacturers. One of the Atabrine licensees was Frederick Stearns & Co., pharmaceutical manufacturers since 1855, with subsidiaries and branches in Canada, Australia, and New Zealand. In 1944 its acquisition by Sterling brought in such products as neosynephrine, amino acids, Fergon, and Astring-O-Sol. Another licensee was the Hilton-Davis Chemical Co., large-scale manufacturers of bulk chemicals, including colors, dyes, inks, and varnishes. This acquisition marked the

most important vertical expansion of the Company, for during the war Hilton-Davis had made, in addition to Atabrine, poison gas and poison-gas detector paint, plasticizers for smokeless powder, sea markers to locate airplanes and life rafts at sea, and colors for smoke screens.

In 1946 Sterling augmented its service to the medical profession by acquiring George A. Breon & Co., the major portion of whose business is with dispensing physicians. Other new products added since 1941 include Campho-Phenique; digitoxin, whose manufacture before the war had been controlled by a few French pharmaceutical houses; and synthetic vanillin, derived as a wood by-product, which the Company had long distributed.

In five years Sterling's sales increased two and one-half times, exceeding $100,000,000 in 1945 for the first time and reaching $121,487,901 in 1946. Its research activities moved ahead even faster. In 1941 its scientific staff consisted of a handful of research workers. By the end of 1946 they numbered more than 150 and long-range plans call for the eventual doubling of that figure. The Sterlin-Winthrop Research Institute was formed as a division of the Company, to be housed in new and modern laboratories adjacent to Wintrop's Rensselaer plant. When completed, the laboratories will permit extension of research in penicillin-like compounds and derivatives, organometallic compounds, sulfa drugs, anti-malarials, veterinary products, barbiturates, amino acids, diagnostic agents, streptomycin, and other therapeutic agents. Studies in tropical medicine will be pursued, with emphasis on diseases common to Latin Americ and the Near East. Research will also be undertaken in packaged medicines, fine chemicals, pigments, and dyes.

Substantial sums are now allocated for research grants and fellowships in almost 100 universities, medical schools, and hospitals; and Sterling's divisions and subsidiaries cooperate with many institutions in clinical investigation and research. The Company today operates on the principle that advancement of knowledge, techniques, and standards is the price of leadership. Each of its plants has a well-equipped laboratory completely staffed to insure the purity of the raw materials and the integrity of what goes out of the plant.

SUMMERS FERTILIZER COMPANY, INC., was incorporated in Baltimore, July 7, 1922, by Walter P. Summers and James E. Totman of Baltimore, and Willis R. Dresser of Calais. Summers for many years had been president of the old-established Hubbard Fertilizer Co. of Baltimore; Dresser had been salesman and branch manager for the American Agricultural Chemical Co. and International Minerals Co., operating in the Northeast since 1900; Totman had joined the W. R. Grace & Co. organization in the Nitrate Agencies Division as New England salesman, following graduation from the University of Maine Agricultural College in 1916, and became manager of the Baltimore office in 1919. With this nucleus, the Company entered fertilizer manufacturing with a small dry-mixing plant in the Canton district of Baltimore. The objective was the distribution of mixed fertilizers in the eastern Atlantic states north of the Potomac. The officers of the Company were: Summers, president; Totman, vice-president; Dresser, secretary-treasurer; and William Fessler, formerly with Nitrate Agencies Co., assistant secretary. The original directors were Summers, Dresser, and Totman.

Two months following incorporation, Summers, at the age of 48, suddenly died and the future operation of the Company fell upon Totman. Baltimore then as now was the fertilizer manufacturing center of the world. Competition was severe and overproduction, created by World War I conditions, prevailed. Old-established companies were not keen to see newcomers. For the first few years it was touch-

and-go as to whether the Company would survive. In 1924 arrangements were made to supply a large Eastern farmers' cooperative with its fertilizer requirements. That year the plant and site of the Hubbard Fertilizer Co. were acquired, with equipment for manufacturing superphosphate and a deep-water pier. September of next year fire destroyed the mixing plant but within 90 days a modern fireproof dual-crane unit was designed by the Company's superintendent, Atkin M. Ingram, and erected by the Austin Manufacturing Co., trebling the original capacity. Ingram also designed and patented the Ingram car—an electric, two-to-four ton car for transporting raw materials. His theories of handling raw materials and excavating den superphosphate by mechanical means are now standard practice.

Eight months later, another fire wiped out the plant, including the superphosphate manufacturing facilities. The ensuing three years were critical for the Company and the industry. A new type "no-filler" mixed fertilizer sustained the Company until better times appeared. By 1929 the Company was again operating at a maximum output and had meantime entered the export field. Under Dresser the business in Maine and eastern Canada was increased and Totman took his three younger brothers, Frank, Reginald, and Kenneth, into the Company.

To avoid import duties, Summers in 1930 organized the Island Fertilizer Co. of Charlottetown, Prince Edward Island, and erected the first mixing plant there. During the same year the plant of the International Agricultural Corp. at St. Stephen, New Brunswick—a dry-mixing factory of 20,000 tons capacity—was purchased. The old-established business and factory of the Sagadahoc Fertilizer Co., Bowdoinham, Me., was also acquired. The local managers of these three operations were Austin Scales, Willis Dresser, and Avery Fides, respectively. The volume now handled placed the Company in the upper brackets of the so-called independent fertilizer manufacturers of the U.S.A.

During the depression, Summers, in common with all fertilizer companies, was forced to retrench drastically. Its interest in the P.E.I. facilities was sold to local parties. The Baltimore facilities were leased to a cooperative under a close working arrangement that still permitted Summers to obtain its Baltimore requirements under favorable conditions. Along with many other resourceful maneuvers, Totman was able to bring his Company through the storm, when the number of fertilizer companies in Baltimore was reduced from 31 to 16. During this period there was little change in Summers' officers and directors. In 1936 Willis Dresser retired and was succeeded by Grant J. Campbell of Baltimore, who was recently succeeded by Dresser's son, Walter E.

With storage and deep-water pier facilities at Searsport and Winterport, Me., Summers built up a leading position in the potato merchandising field. This business is conducted through the Penobscot Warehousing Co., formed in 1935; the Winterport Terminals, Inc., organized in 1938; and the A. E. Mooers Co., Inc., acquired about the same time.

At the outbreak of World War II, when the Government requested large quantities of dehydrated potatoes for the Army and Navy, Summers organized the Maine Food Processors, Inc., and installed a potato dehydration plant in the Winterport Terminal facilities. This operated successfully until a disastrous fire in 1944 curtailed operations for the time being.

The war called for a tremendous increase in potato acreage and consequently fertilizer consumption in Maine. To meet this demand, Summers organized the Northern Chemical Industries, Inc., and in the fall of 1943 began building a 75,000-tons per annum superphosphate plant designed by William Gabeler. Production commenced in July 1944 under Gabeler who next year was succeeded by Ralph Fraser, now a vice-president. Under Fraser, Summers acquired the dry-mixing

business of Colbath & Anderson, Mars Hill, Me., and of Callnan Bros., Houlton, Me. In July 1946, Frederick Litty, formerly vice-president in charge of production of Davison Chemical Co., became vice-president and general manager of Northern Chemical Industries and Summers' interests at Searsport.

Meanwhile the Baltimore facilities originally leased to a cooperative producing mixed fertilizer were sold by Summers to the lessee. Thereupon Summers bought outright the Griffith & Boyd Fertilizer Co. of Baltimore, and took over George Bratt, its president, and George Biddison, treasurer. Vice-president J. E. Griffith, son of the original founder, was succeeded by N. Kenneth Totman, treasurer of Summers, and William Bird, formerly superintendent at the Searsport plant, became plant manager.

During its entire existence Summers handled as distributor a large portion of the sardine meal output of Eastport, Me. This area is the largest sardine-canning section in the U.S.A. and third largest in the world. Late in 1945, Summers' subsidiary, the Maine Food Processors, purchased the fish meal plant of the Globe Canning Co. of Eastport. The first year's operation proved the largest output in many years of meal and sardine oil. At present, research and experiments are being carried on to produce amino acids and other medicinal items from fish products and waste, at the Company's laboratory at Searsport. In Nov. 1946, through its Penobscot Warehousing Co., Summers purchased the fertilizer plant and deep-water facilities of the Hartwell Coal Co. and have remodeled them to handle the dry-mixing operations of Summers, leaving Searsport exclusively for superphosphate production. This will increase Summers' capacity to 50,000 tons of mixed fertilizer per annum for Maine.

Summers' foreign interests are closely affiliated with those of the Diamond Fertilizer & Chemical Co. of London whose president, Arthur Van Den Bergh, is interested with James Totman in several of Summers' business ventures.

The present officers of the Company are: James E. Totman, president; William A. Fessler, vice-president, with the Company for 25 years; Ralph E. Fraser, vice-president in charge of Summers' activities in Maine; N. Kenneth Totman, treasurer, as well as vice-president of Griffith & Boyd; Doris C. Zaiser, secretary; and Howard J. Miller, assistant secretary. The directors are J. E. Totman, Fessler, F. H. Totman, Fraser, N. K. Totman, L. A. Spalding, J. H. Skeen, W. R. Hubbard, H. E. Nickerson, B. C. Parkhurst, H. E. Miller, J. G. Matthews, and G. A. Bratt. Spalding and Skeen have served continuously on the board for 22 years; Hubbard, son of one of the original owners of the Hubbard Fertilizer Co., for 17 years. The Company's offices are at the location where it started 25 years ago, the Baltimore Stock Exchange Bldg., 210 E. Redwood St., which Summers now owns and operates.

SUN CHEMICAL CORPORATION'S name was adopted Nov. 28, 1945, but its history extends back 106 years. It succeeded the General Printing Ink Corp., formed in 1929, which comprised a number of printing ink companies, a pigments department, and the Rutherford Machinery Co., manufacturers of lithographic cameras and equipment. In the new company in which altogether 27 companies were combined, the General Printing Ink Division was maintained to operate printing ink units. In 1945 General Printing Ink Corp. had acquired the paint business of A. C. Horn Co. and its subsidiaries, and of the Hudson Paint & Varnish Co. and C. A. Willey Co. Shortly after the incorporation, Sun Chemical bought the business of the Warwick Chemical Co. and its subsidiaries, manufacturers of textile finishes, stearates, and microcrystalline waxes.

The oldest company in the group which became Sun Chemical Corp. was Geo.

H. Morrill, established in 1840 by Samuel Morrill. He was born in Salisbury, Mass., and had been apprenticed to Flagg & Gould, printers in Andover, Mass., in whose plant, in 1827, he operated the first power-printing press in New England, on which he printed *The Worcester Aegis.* He formed his own company in 1840 for the manufacture of newspaper ink, his first customer being the newspaper, *The Worcester Spy.* The ink was made from lampblack which was boiled with linseed oil on his kitchen stove, and delivered from town to town in cans in his own horse and buggy.

A plant was later built in Norwood, Mass., and Morrill ink became the standard ink of most newspapers. The growth of population and its movement westward permitted rapid expansion of the printing ink business and in 1867 a branch was opened in San Francisco. In 1880 special inks were made for the newly developed half-tone screen which permitted reproduction of photographs. In 1882 three-color process printing was invented, for which suitable inks were developed. In 1898 the first high-speed newspaper presses were installed, requiring further improvements in ink. In 1917, when German submarines cut off the Company's supply of aniline dyes, Morrill chemists developed their own processes and built a plant to make aniline and pigments therefrom for newspaper and other colored inks.

As the needs of the publishers of the country grew with expanding circulations and high-speed presses, service on printing inks required delivery from Philadelphia, Chicago, and San Francisco, so tankcar and tank truck delivery from these points was provided. For many years Geo. H. Morrill has been the world's largest producer of newspaper printing inks. The increasing use of color in newspaper printing has created demand for colored inks and for service on their delivery equal to the service on black inks.

Other companies in the General Printing Ink Division of Sun Chemical Corp. have interesting early histories. Sigmund Ullman was established in 1861 and has become famous for publication inks used by the great magazine publishers. The Ullman plant is on Park Avenue at 145th St., Bronx, N. Y. This company developed doubletone inks and, as the printing business developed, brought out many new special inks, such as metallic finish inks simulating copper, silver, and gold surfaces; gloss inks for labels and covers requiring hard finish; scratch-proof ink for labels and packages where durability is important; and overprint varnishes. The increased production speeds of color presses used by the big circulation magazines have necessitated effective formulas for color-process inks which print on thin magazine stock. Precise control of viscosities is required so that each color, as printed, may trap and hold the ink of the next succeeding color.

Fuchs & Lang was founded in 1870 and pioneered in the lithographic processes and in equipment and inks for metal decorating. The chemistry of lithographic printing is based on the simple fact that water and grease do not mix. The image is covered with grease, the nonprinting surface with water; the grease attracts and holds the ink when applied, and the water repels it. This principle governed the original process when lithography was a process of drawing the image in reverse on stone and printing it in one color on a flat-bed press. The later high-speed developments which have led to a process involving cylinder presses with metal plates printing a number of colors against a rubber blanket which in turn "kisses" the paper, has not changed the basic principle. Nevertheless, each step in the improvement of the lithographic process has required changes and developments in the inks required.

Other ink companies in the General Printing Ink Division include Eagle Printing Ink, established in 1893, makers of fine process inks, and the American

Printing Ink, established in 1897, specializing largely in catalog and gravure inks.

Chemical Color & Supply Co. was organized in Chicago in 1931, to develop and market compounds used by printers in the preparation of inks for use on the press, and to maintain the condition of the ink during printing operations. Subsequently, job inks were added to the line. Special inks, such as Single Impression White, became featured products of the company which in 1937 became a part of General Printing Ink Corp.

In Feb. 1945 General Printing Ink acquired the E. J. Kelly Co. and Michigan Research Laboratories of Kalamazoo, Mich. These companies had developed a new type of printing ink based on a different principle. Under this principle, pigments are dispersed in synthetic resin and an odorless organic solvent having a high boiling point. Being miscible with water, this solvent may be flushed out of the ink by the application of small quantities of moisture by means of steam applicators, setting the ink instantaneously. The ink will also set in 10-20 minutes by absorption of atmospheric moisture. The patents covering the manufacture of this ink and its components are owned by Michigan Research Laboratories: U. S. Pats. 2,244,103, 2,261,798, 2,289,638, 2,299,135, 2,300,880-1, 2,309,580, 2,313,328, 2,323,710, 2,327,594-7, 2,332,066, 2,336,983-4.

All of the companies of the General Printing Ink Division manufactured their products by the processing of oils, pigments, and resins. After their amalgamation in 1929 their common functions, such as purchasing, accounting, and research were centralized, but the sales forces continued operating as individual units. Research expanded rapidly. The technical routines of quality control of raw materials and of manufacturing were maintained at the individual plants. New fields of application were developed and pure research was instituted by the central research organization. Its work included the study of oils, resins, and pigments and their application, evaluation of color characteristics by spectrophotometry and precise measurement and control of ink viscosities; dispersion of radioactive substances with pigments in ink mixtures for the measurement of minute values to control pigment dispersions. The availability of new synthetic resins has required constant research and experiment to develop methods of dispersing such resins in vehicles suited to the manufacture of ink.

With its skill in processing these materials, the Corporation had a natural interest in the manufacture of paints and industrial finishes because of the similarity of the raw materials and manufacturing operations. Its acquisition in 1945 of the paint business of A. C. Horn Co., Hudson Paint & Varnish Co., and C. A. Willey Co., was therefore a natural step. There was also a great interest in chemicals used in textile finishing. The Warwick Chemical Co., which specializes in textile treatments and finishes, also made stearates and waxes so that some of its products were available as raw materials for use in paint and ink. Other Warwick products include the textile water repellents, Impregnole and Norane. The A. C. Horn Co. was founded in 1896 and its paints and building maintenance compounds had a long and successful record of use on buildings. One of its products, Waterfoil, is used in treating new concrete or masonry to repel moisture.

Currently a program of rearrangement and integration of the manufacturing operations is going forward at all plants in the Sun group, to meet one or more of the following purposes: (1) grouping products requiring the same raw materials; (2) grouping products requiring the same machinery and equipment for production; and (3) grouping products sold to the same class of customers. When this program is completed, the geographic location of Sun plants will give regional production facilities in each part of the country for all the products of the Corporation. The plants are located at Norwood, Mass.; West Warwick and Richmond,

R. I.; East Rutherford, Jersey City, North Bergen, and Harrison, N. J.; Long Island City and Bronx, N. Y.; Rock Hill, S. C.; Chicago; Chanute, Kans.; Kalamazoo, Mich.; Houston, Tex.; Los Angeles and San Francisco.

The officers of Sun Chemical are Albin K. Schoepf, president; J. W. Raynolds and Wm. Recht, vice-presidents; Charles R. Sherman, treasurer; and Sherwood Bonney, secretary. The Division presidents are John F. Devine, General Printing Ink; A. E. Horn, A. C. Horn; A. C. Horn, General Industrial Finishes; and Ernest Nathan, Warwick Chemical. Its directors, beside Schoepf and Raynolds, are: LeRoy W. Campbell, W. G. Dunnington, Frederick H. Farnsworth, A. C. Horn, Arthur E. Jones, R. V. Mitchell, T. E. Richmond, Geo. W. Ullman, and Morris Weil.

SUNLAND INDUSTRIES, INC., of Fresno, Calif., are processors of agricultural chemicals and seeds, distributed through retail outlets on the Pacific Coast, particularly in California. The Company also does some exporting. Four major departments comprise the organization: Sulfur, Insecticides, Fertilizers, and Seeds.

Sunland's history starts in 1925, when T. L. Harper and B. H. Jones purchased the California Associated Buyer's Co. of Fresno, and operated it as a retail establishment, furnishing all types of ranch supplies to farmers. The firm took the name "Cabco" from the initials of its predecessor company. In carrying on these activities, the partners recognized the need for a sulfur mill in the San Joaquin Valley to supply dusting sulfur and similar products to the grape and fruit growers. They were convinced that it would fill a real need in the agricultural community and could be operated successfully. On Aug. 13, 1930, they organized the Sunland Sulphur Co., Inc., under the laws of California, to manufacture and process sulfur products for sale through distributors and dealers. A Raymond sulfur mill was erected on a site purchased in Fresno. The retail activities of Cabco were continued until 1939, when this operation was discontinued and its customers were encouraged to purchase Sunland products through dealer channels.

Throughout the 1930's the Company expanded, adding new lines and extending its sales territory. In 1932 insecticides were added; simple fertilizers, in 1934. A plant for manufacturing mixed fertilizers was added in 1937. Late in 1939 a modern seed plant was installed to clean and process field and cover crop seeds. With this growth and the establishment of these new departments, the management realized that the name Sunland Sulphur Co did not adequately represent the nature of the organization. Therefore in Jan. 1944, the Company took the new name, Sunland Industries, Inc., with no change in location, ownership, management, or personnel.

After Harper's death in Dec. 1945, Jones became president, with Frank A. Easton as vice-president and general manager, Dr. G. F. MacLeod as technical vice-president, Mrs. Gladys Harper as secretary. The foregoing, plus J. H. Wright, are directors.

SWIFT & COMPANY came into being as the result of the idea of its founder, Gustavus F. Swift, that meat-packing operations should be located in the West near the livestock supply, and that fresh meat, rather than live animals, should be shipped to consumer markets. Chicago offered an ideal location, so he went there in 1875 as a cattle buyer and two years later entered the meat-packing business. Years of natural expansion followed until at present (1948) the Company operates about 50 meat-packing plants besides many dairy and poultry plants, re-

fineries, oil mills, soap, cleanser, glue and adhesive factories, fertilizer plants, and animal feed plants, all strategically located across the nation, the processing units near sources of supply and the distributing units near areas of demand.

Remarkable research work has been done in developing uses for the great deal of otherwise waste material obtained in processing cattle, hogs, calves, and sheep. A partial list of these by-products includes hides and skins, wool, glue, fats, hair and bristles, glycerin, soap, animal feed, pharmaceutical glands and extract. Manufactured food products which utilize animal portions other than carcass meat, include lard, margarine, sausage, gelatin, soup concentrates, and cooked meats.

Development of the refrigerator car and use of mechanical refrigeration plants were two important improvements that preceded organized research. Before mechanical refrigeration, pipes were embedded in ice-salt mixtures and air was blown through them for chilling. The cold air was conveyed into the coolers and the warm air was again recirculated through the pipes. This method worked surprisingly well but was expensive. About 1880 the first mechanical refrigerating plants were installed in Chicago's packing houses. Ammonia, then as now, was the gas compressed and made possible not only coolers but large refrigerated warehouses. However, it did not solve the problem of getting Western dressed beef to Eastern markets. Early attempts at complete refrigerator cars featured efficient insulation on the outside with built-in bins for ice on the inside. This was not efficient, first, because there was no provision for air circulation, and second, the car could be iced only when empty. Many improvements in refrigerator car design took place from 1861-70, but all dealt primarily with a more efficient use of ice rather than with the importance of air circulation. G. F. Swift and Warren A. Chase, an engineer from Boston, visualized that "a current of air allowed to pass through an ice bunker in the upper corner of a car becomes chilled so that it is heavier that the air with which it comes in contact and consequently sinks and circulates through the car, the warm air passing out through the ventilator." This principle was applied to the refrigerator car and the rise of the great centralized meat-packing industry in Chicago began.

Although the successful refrigerator car solved one problem, it created others. The fight to establish a dressed beef traffic and market in the East was long and arduous. There was definite prejudice in New England against Western dressed beef and it was 10-15 years before this was overcome. Another factor was the opposition of the railroads which could see no advantage in the shipment of carcass beef which represented only 60% of their former live-animal tonnage. Local Eastern butchers, unable to cope with the extension of dressed beef, tried legislative methods to bar the Western product. All of these obstacles were overcome by 1894.

Organized research began at Swift in 1890. It had long been standard practice to manufacture fertilizer and animal feed from waste fat and flesh. To meet the requirements of commerce it was necessary to name on the package the content of these products, so Swift hired a chemist—the first of hundreds—to analyze them, and from that time on the laboratories have steadily grown. In 1892 a laboratory was established at Chicago to analyze and standardize products, and to assist in manufacture of products as well as exploitation of by-product. With each new meat-packing plant built or purchased, went a new laboratory. These early laboratories were at St. Louis in 1900, Kansas City and St. Joseph in 1905, Fort Worth in 1906, and subsequently in Omaha, East Cambridge, Portland, San Francisco, Los Angeles, St. Paul, Newark, E. St. Louis, Edmonton, Toronto, Harrison, and Atlanta.

By the 1920's the meat-packing industry had standardized on two general types of by-products, in addition to the major products: the primary, produced and sold

without appreciable processing, as blood, hides and skins, hoofs and horns, hair, bones, fats, intestines, bile, glands, and inedible trimmings; the secondary, resulting from further processing of primary by-products and which may or may not be carried on by the meat packers themselves, as poultry and livestock feeds, fats, soaps, glycerin, margarine, fatty acids, sausage casings, glue, gelatin, and pharmaceuticals.

Prior to this period few meat products except for the main carcass were considered worth saving—"the heads of hogs were buried in carload quantities merely to get them out of the way." The story has it that when G. F. Swift learned that an owner of a fine carriage was obtaining his money by skimming the water into which the packing houses were discharging their wastes, he instituted rigorous economy. Catch basins were installed throughout the plants whereby efficient separation of fats, water, and solids could be effected. In the last 15 years these processes have been improved so that additional protein material can be flocculated and separated.

Lard has come a long way from a grainy, yellowish, pork-flavored household fat to the stabilized, creamy product with neither color nor flavor. This improvement came in the late 1920's or early 1930's, with the application of catalytic hydrogenation in the vegetable oil shortening field in this country. Earlier, kettle rendering of animal fat was replaced by high-pressure steam rendering, and steam deodorization under reduced pressure took place in the early 1900's when the steam ejector as a source of vacuum was developed. About 1890 vegetable oils became constituents of margarine and the meat-packing industry entered this new field since it had in the product stearin a means of hardening. Between World War I and II extensive searches for edible antioxidants which stabilize edible fats are among the foremost contributions of the industry.

Between 1900 and 1915 Sabatier and Senderens discovered that hydrogen could be added to olefinic linkages in hydrocarbons or any fat. The importance of this discovery was not then appreciated, but it has made possible production of food fats from raw material other than animal fat and is indirectly responsible for almost doubling the amount of harder fats available in this country. Catalytic hydrogenation of vegetable oils can be regulated and controlled to obtain the desired consistency of the final product. Thus cottonseed oil can be hydrogenated until it is a hard, brittle wax or only to the point where it is plastic and similar to lard. The vegetable shortening industry was born in 1914-18. More recently Sabatier's hydrogenation has been improved and applied to countless fats so as to produce a wealth of raw materials, one of the more important being the higher fatty alcohols. Edible emulsifying and surface-active agents came into prominence by 1930, and today partial esters of edible polyhydric alcohols are found in margarine, shortening, peanut butter, mayonnaise, ice cream, and other foods.

Although the preparation of gelatin is an old art, today's large-scale industrial process requires close chemical control to produce odorless, colorless, and practically sterile gelatin with no added preservatives. Here the technical man has not been too concerned with the development of substitutes but has concentrated upon new and highly specialized uses in the food industry and in the manufacture of photographic film and capsules.

Research with animal glue has led to the development of chemical liquifiers which permit the use of animal glue without heat. More recently certain applications of proteins obtained from collagen-bearing material have been shown to have excellent emulsifying and protective colloid potency.

Organic fertilizers began to lose importance as a by-product of the meat-packing industry during the First World War and eventually died a slow death. The

American farmer had found that chemical plant foods were not only more efficient and better balanced but cheaper because animal materials had higher value as feeds.

In the late 1930's new developments in canning and dehydration of meat were under way. No one ever dreamed that so much food value could be compressed in such a small area as was effectively done throughout the food industry in general and the meat-packing industry in particular. The packing industry concentrated food products for the Quartermaster Corps, which ranged from canned ham and eggs to baked ham with sweet potatoes and raisin sauce. In 1946 Swift made available finely comminuted canned meat free of fat and connective tissue, as a natural source of protein for infants and invalids.

At the present time the Company has 29 zone laboratories and 150 process control test rooms scattered across the nation, which perform an estimated 2,000,000 analyses each year. All function under the central research laboratory in Chicago, with four main objectives: (1) development of new products and processes as well as improvement of old; (2) product and quality control; (3) sanitation; and (4) nutrition. To attain these objectives, Swift devotes much attention to customer problems and assistance to homemakers.

The research laboratories comprise about 22 divisions. Many groups work with fats and oils, dairy and egg products, fresh meats, cured meats, soap and detergents, glue and adhesives, margarine, plant foods, or phosphate rock. Others conduct original investigations in physics, physical chemistry, nutrition, biochemistry, bacteriology, histology, analytical methods, veterinary medicine, and home economics. Scientific studies pointing toward a better-fed America are part of Swift's outside research program: grants-in-aid to universities and colleges for basic studies in foods and general agricultural problems, and nutrition fellowships for basic research in human nutrition. Grants-in-aid totaling $800,000 during 1943-47 supported long-term basic studies, most of which will continue from three to five years. Nutrition fellowships totaling $50,000 a year have been divided among some 28 schools during the past five years. Swift & Co. has no prior claim on the results of these research findings, but offers their benefits to all producers and consumers of food. They are the result of a growing interest in human nutrition, and are inspired by the belief that good nutrition begins with the soil. As a major processor and distributor of important basic foods the Company has accepted as a responsibility the support of research upon basic agricultural and food problems, primarily because nutrition is its business.

SYLVANIA INDUSTRIAL CORPORATION, since Sept. 1946 the American Viscose Corp., was organized Apr. 1929, by Dr. Roger N. Wallach, former head of Grasselli Dyestuff Corp., who acquired rights to the Belgian-owned U. S. patents for cellophane manufacture. Associated with him was Dr. Frank H. Reichel as vice-president in charge of manufacture. The head office was then in N. Y. City and the new plant was built at Fredericksburg, Va., in 1930, with four cellophane-spinning units. In Feb. 1934 the Company was reincorporated in Virginia and its head office was moved to Fredericksburg, which started out with 150 employees and now has 2,000.

In 1930 the Company produced only one type of cellophane. As a result of a vigorous research and development program, it now manufactures over 30 different types, each for a specific purpose. Sales policies under the direction of vice-president Harry H. Replogle, who retired Jan. 1, 1946, and was succeeded by John W. Little, were tied in with this program of research and expansion.

In 1932 Sylvania introduced heat-sealing cellophane, which rapidly displaced the old method of sealing by adhesive or solvents, and in 1935 developed the first

flame-retarding or flame-resisting cellophane. In 1938 it introduced two different types of moistureproof cellophane which will not become brittle at freezing temperatures, for the frozen food industry. About the same time, it developed a special wrapper for candles and other wax products. During World War II, many new types of cellophane were developed for war purposes and a large number of these have since been adapted to commercial use.

Self-shrinking viscose bands for bottles and jars were added to Sylvania's products in 1932. Three years later the Company began manufacturing casings for meats, which are made from denitrated nitrocellulose instead of viscose and come in a wide range of sizes. A completely equipped printing plant is operated for these casings for which special inks and processes have been developed.

The manufacture of cellulose ethers was begun in the fall of 1935 with a type for textile finishing, sold under the trade name of Ceglin. Other types for textile finishes and ethers for use in food products have since been added.

Sylvania owns three sales subsidiaries: Sylvania Industrial Corp. of Canada, Ltd.; Sylvania Industrial Corp. of Georgia; and Sylvan Plastics, Inc., which sells Sylplas, a variety of urea-formaldehyde resins which Sylvania has been manufacturing since the spring of 1941.

Dr. Wallach continued as president until 1938, thereafter as chairman of the board until his death on Pearl Harbor Day in 1941. Dr. Reichel succeeded him as president in 1938 and is at present chairman of the board and president of the American Viscose Corp. Technical research has been under the supervision of Dr. Ralph T. K. Cornwell, formerly of Cornell University.

TAKAMINE LABORATORY was founded by Jokichi Takamine, chemist, inventor, and publicist of international renown. Born on Nov. 3, 1854, the year Commodore Perry opened Japan to international development, young Takamine, at the early age of 12, was among the few other promising young Japanese selected to receive every educational advantage in Japan's new resolve that only by adopting the arts and sciences of the Occident could she cope with the new pressure thus brought to bear upon her. Shortly after he was 18, Takamine entered medical school at Osaka. Before long, however, he switched to chemistry, graduating in science and engineering. He spent three years in Glasgow University and Andersonian University, England, and during summer vacations visited factories, especially those manufacturing soda and artificial fertilizer, in Newcastle, Liverpool, Manchester, and other industrial centers.

Takamine returned to Tokyo in 1883 and was given a position in the Department of Agriculture & Commerce. The following year he was sent to the United States to attend the International Cotton Exposition in New Orleans, as one of the commissioners of the Japanese Government. On Takamine's return to Japan, he brought with him a small quantity of phosphate fertilizer he had bought in South Carolina. Leaders in Japan's industrial and commercial world saw possibilities in the fertilizer industry and organized a corporation known as the Tokyo Artificial Fertilizer Co. At its request, Takamine, in Mar. 1887, went abroad for the third time, visiting the principal agricultural countries of Europe and in the summer arriving in the United States, where he purchased the necessary machinery for the fertilizer industry. Before returning to Japan, he stopped in New Orleans to marry his fiancée of two years, Caroline Hitch, daughter of E. V. Hitch, a Colonel in the Northern Army.

In 1890 Dr. Takamine permanently returned to the United States and first settled in Peoria to develop the use of his pure culture fungus diastase in the distilling field. He established the Takamine Ferment Co. to introduce his enzyme

process in the distilleries at Peoria and in many other fields. After a few years Dr. Takamine located in Chicago, where he continued his industrial and medical research.

Dr. Takamine's outstanding discovery, the hemostatic, adrenalin, came at the turn of the century after he had left Chicago and established a laboratory in New York. In the years which followed, this laboratory was twice outgrown, so he determined to find quarters adequate for both research and for the manufacture of his enzyme products. He accordingly incorporated the Takamine Laboratory in 1915 and moved it to Clifton, N. J., where he purchased a plant with considerable acreage to permit future expansion.

During World War I, millions of gallons of Polyzime Liquid were manufactured for use in the preparation of textile products for the Army and Navy and, at the request of the Food & Drug Department, Takamine Laboratory produced tremendous quantities of Arsaminol (606) for the Government, being granted Federal Trade Commission License #1 to do so. The Clifton plant expanded rapidly after the introduction of enzyme products in dry, concentrated form, Clarase being developed for many phases of the food industry in 1922, followed by Polyzime "P" (Powder) for textile use in 1924.

Following Dr. Takamine's death in 1922, Jokichi Takamine, Jr., was president of the Takamine Laboratory until his death in 1930, when Eben T. Takamine, Dr. Takamine's second son, succeeded. During the late 1920's and early 1930's, the Company produced enzyme specialties in rapid succession which have found successful use in many industrial and food processes.

Again in World War II, Takamine Laboratory, Inc., took a leading part in supplying textile enzymes to plants making various types of fabrics for the war effort, as well as specialized enzymes for a number of other companies. One of its outstanding developments was the production of an unusually effective enzyme for the preparation of protein hydrolysates, so valuable in the treatment of malnutrition. Other specialized enzymes were produced for use in assaying vitamin B_2 and in testing penicillin for sterility.

The Company maintains extensive research and development laboratories for investigations of all possible industrial uses of enzymes. It stands as a living monument to the memory of its founder and his faith in the useful application to humanity of a microscopic fungus which catalyzes some of the most important chemical reactions known to science and yet itself takes no part in them.

TEXAS GULF SULPHUR COMPANY'S Big Hill in Matagorda County, Tex., is another example of a sulfur dome that was first drilled for oil. Prior to 1923 every sulfur deposit was found in drilling for oil, and subsequent discoveries were made on domes located by oil companies through geophysical methods. The discovery of oil at Spindletop, Tex., in 1901, provided the efficient cheap fuel necessary to make Herman Frasch's attempts to mine sulfur in Louisiana commercially successful. It further influenced the history of the American sulfur industry in that it brought about widespread prospecting for oil in the domes on the coastal plains of Texas and Louisiana.

By 1905 Big Hill was abandoned as an oil field, but some drilling had disclosed the presence of sulfur. Consequently two or three years later, A. C. Einstein and John W. Harrison of St. Louis and a group of local residents drilled some wells expressly to prospect for sulfur. It was not until 1916, however, when Col. Seeley W. Mudd, a well-known mining engineer, and his assistant, Spencer C. Browne, became interested, that any great strides were made in developing what could be called a large body of sulfur. Col. Mudd enlisted the interest of Bernard

M. Baruch, J. P. Morgan, and Col. William Boyce Thompson, and shortly thereafter acquired control of the Gulf Sulphur Co. which had been formed by the St. Louis group. One of the first actions was to acquire the necessary land and mineral interests to make possible a profitable mining operation, and Col. Mudd, as first president of the Company, in 1917 initiated a program of drilling under Browne's direction. This drilling indicated the presence of sulfur in sufficient quantity to justify plant construction at some later date.

In Mar. 1918, Col. Mudd resigned to go into war work and his place was filled by Walter H. Aldridge, chief engineer in charge of the Thompson mining interests. Aldridge, who had made an outstanding record while directing the mining and metallurgical operations of the Canadian Pacific R.R. in Western Canada, has been president of the Company throughout its entire history as a producing organization. In July 1918, shortly after he became president, the name was changed to Texas Gulf Sulphur Co.

There had been no intention at that time to construct a plant at Big Hill, but in view of the wartime requirements of the Government and its allies, the Company agreed to bring "the property to a production stage at the earliest possible moment and to provide all necessary funds for this purpose." Although construction moved at record-breaking pace, it was not until Mar. 1919 that hot water could be pumped into the deposit and sulfur actually produced. The Company not only started too late to supply any of the war business, but found itself entering a market already supplied by two firmly established companies with capacity for high production and large stockpiles of sulfur. Confronted with the problem of finding a market, Texas Gulf decided to go after a potential consuming industry largely ignored by other producers prior to the war, the makers of sulfuric acid. It was successful in switching many permanently to brimstone and by 1925 was supplying about 40% of the market for American sulfur. Next year, when the Union Sulphur Co. announced it would no longer make contracts for the sale of sulfur, the Company was called upon to supply even a larger portion not only of the domestic but also of the world market for American sulfur.

In 1927 a contract was signed with the Gulf Production Co. under which Texas Gulf acquired the right to prospect and explore properties upon which Gulf had leases or mineral rights. By the end of the year drilling disclosed a large quantity of sulfur at Boling Dome, Tex., and in May 1928 construction was started on a sulfur plant and the necessary townsite, which was named Newgulf. The plant was completed in about nine months and in Mar. 1929 the first sulfur was produced from what has proved to be the largest sulfur deposit ever discovered. The same year drilling at Long Point confirmed the existence of a small sulfur deposit, and in Mar. 1930 came the first production. From 1932-35 operations of the Company's wholly owned original property at Gulf, Tex., were suspended. Jan. 1936, production was resumed, but only a relatively small additional quantity was produced, and the mine was abandoned the latter part of the year.

Toward the end of 1938, after sulfur under one of the tracts upon which the Company held lease at Long Point had been exhausted, operations there were suspended, the interests, however, in sulfur still unmined being retained. This left Boling Dome the Company's sole producer, but well able to handle all demands made on it.

In 1939, with the outbreak of war in Europe, the Company was prepared with a sulfur stockpile of well over 2,000,000 tons. In spite of the tremendously increased demands, stocks on hand in Sept. 1945 were approximately of the same figure. This maintenance of inventory was accomplished despite shipping demands on the Company which had increased from 900,000 tons in 1938 to more than

2,000,000 tons a year within three years. The war demand for ships necessitated a radical change from the prewar practice of shipping 85% of the sulfur by vessel from Galveston, and the bulk of these shipments moved by all-rail from the mines with some shipments continuing by barges on the inland waterways. In spite of the added burden at the mines no consumer suffered from a shortage of sulfur at any time, and Texas Gulf employees won the Army-Navy "E" five successive times.

The efforts of the Company for over 25 years have been devoted exclusively to the mining, shipping, and use of sulfur. Early in its history, the need was seen for research and experimentation in the machinery of producing and handling sulfur, in the design of equipment for its most efficient use, and in its application both in industry and agriculture. As a result, a broad research program has been developed to promote and perfect the uses of sulfur in many and various fields.

THIOKOL CORPORATION was founded in 1929 by Bevis Longstreth to manufacture "Thiokol," the first commercial synthetic rubber produced in the United States. This had been discovered in the early 1920's by Dr. J. C. Patrick, a consulting chemist of Kansas City, when he was attempting to develop a new anti-freeze solution from ethylene dichloride and sodium polysulfide. He accidentally produced this rubber-like material which would not only stretch and bounce, but could be vulcanized, and unlike natural rubber, showed resistance to gasoline, oils, and most commercial solvents. The new material was also resistant to sunlight and oxidation. Principal stockholder at the time of incorporation of Thiokol was Case, Pomeroy & Co. of N. Y. City. Longstreth was made president and Dr. Patrick became vice-president in charge of research. In the course of studying and developing the material, difficulties were encountered. It was hard to work or process, it emitted tear gas at high temperatures, and it had a disagreeable odor. It stiffened at low temperatures and its physical properties were not equal to natural rubber.

The small plant in Kansas City proved to be too far away from the principal markets; therefore, in 1931 a plant was located in Yardville, N. J., from where shipment to and contact with the principal rubber-manufacturing centers of the United States and Europe were easily maintained. Through arrangements with Seiberling Rubber Co., its development engineer, Frank Kovacs, was placed in charge of production and he did a great deal to establish plant processes and procedures at Yardville. Progress at first was slow, but industrial uses were found and the volume of business increased annually.

In 1938 an arrangement was made with the Dow Chemical Co., which was already manufacturing some of the constituent chemicals, under which the latter would manufacture certain of the "Thiokol"-type synthetic rubbers and Thiokol Corp. would handle sales and research. That year, the Company's laboratories and offices were moved to Trenton, N. J.

The volume of the Company's business had increased previous to the outbreak of war, because of military demands. After war broke out, more and more production was required for war uses. Additional plant facilities were immediately made available at Dow and a plant was also installed by the Company at Trenton to produce a particular type of polymer for a special war application. By late 1943, however, the first crisis in rubber was past. The special product made at Trenton was no longer needed and by the early part of 1944 the Company's total business had shrunk considerably. To meet competition, the Company's research program was considerably broadened so that additional and more diversified materials might be discovered. Thiokol products are not meant to replace natural rubber in industry, but to do jobs that natural rubber or other products cannot do or does un-

satisfactorily. The "special polymers" made are sold as raw materials to rubber manufacturers who compound, process, shape, or vulcanize them into finished articles. The Company also markets several plasticizers and compounding ingredients used in rubber, and a line of special chemicals.

Thiokol Corp. maintains a well-informed technical sales staff and markets its own products domestically. It has agents in Europe, Canada, South America, South Africa, and Australia. A technical service department assists regular customers in solving their various problems. While a great many "Thiokol" fabricated products are made by the rubber industry, they are also used by other companies for coating and caulking compounds, tank-lined materials, sealants, coatings, putties, and hose. All are protected by patents.

In 1945 a fellowship was established at Princeton University to study the physical chemistry of polysulfide polymers.

THOMPSON-HAYWARD CHEMICAL COMPANY was incorporated in Missouri, Jan. 11, 1917, as Thompson-Munro-Robins, a sales organization with offices and warehouse in Kansas City and St. Louis. Capitalization was $8,000, with $3,000 cash paid in. The officers and original directors were: Charles T. Thompson, president; George S. Robins, vice-president; George E. Munro, secretary-treasurer, Munro left the Company in 1919 to be manager of McLaughlin, Gormley & King's New York office. Robins sold his interest in 1923, when he opened his own business in St. Louis.

Following World War I, the Company established foreign connections to import items not produced in quantity in this country. Research offices and warehouses were opened in Des Moines, Denver, Tulsa, Minneapolis, Omaha, New Orleans, Wichita, Memphis, Oklahoma City, Chicago, Davenport, and N. Little Rock. During the years of expansion, the sales personnel has increased from three to 90, employees from seven to 350.

A separate company was organized, Nov. 12, 1926, known as the Thompson-Hayward Chemical Co. of Texas, with main office at Houston, and branches in Dallas, San Antonio, and Corpus Christi. The original directors and officers were: Charles T. Thompson, president; Karl Frambach, vice-president; Edna Frambach, secretary; G. M. Hayward, treasurer.

In 1926 a processing unit was established at Kansas City to mill drugs, perform mixing operations, and supply special formulas for other firms, and to produce standard chemical specialties. The Company has dealt in basic industrial chemicals and allied products throughout most of its existence. In the last few years it has expanded its operations into chemical specialties such as weed killers, agricultural insecticides, and vitamin products.

In 1939 the Alabama Charcoal Co. plant at Baron, Okla., was acquired and is still in operation. During the years, a lime and sulfur plant was installed, as well as a variety of other manufacturing operations. Among these were a fat-splitting unit, specialized coating unit for fiber cartons to handle Buna rubber (a war project), laundry detergent unit, distillation units, and a complete testing and research laboratory.

Gross assets of the Company have increased to more than $4,000,000. The present officers of the Missouri company are: Charles T. Thompson, president; F. M. Goodwin, vice-president; R. E. Ballinger, secretary; and J. T. Lockton, treasurer; who with J. F. Cavanaugh are also directors. The Texas company officers are Thompson, president; K. A. Frambach, vice-president; E. W. Skillern, secretary; Lockton, treasurer. With E. R. Frambach, these constitute the board of directors.

TILDEN COMPANY, originally named E. Tilden, then Tilden & Co., is said to be "the oldest manufacturing pharmaceutical house in America." The substantial home offices, laboratories, and factory in New Lebanon, N. Y., are a good stone's throw from the original plant established in 1824 for the production of Tilden's Patent Chlorine, cosmetics, and pills. An early edition of the Company's price list offers over 160 crude drugs, some 22 extracts and inspissated juices, several ointments, pills, and sirups. Throughout its almost a century and a quarter of business, the Tilden Co. has never advertised or offered its products to the public, but has preferred to deal directly with the medical and allied professions. It saw stirring events and a mighty era of progress in the United States: the annexation of Texas; the inventions of the telegraph, sewing machine, reaper, steam fire engine, etc.; the Civil War; a vast immigration; the development of the West.

Industrious, intelligent, Connecticut-born Elam Tilden founded the Tilden Co. One of his sons, Samuel J. Tilden, became Governor of New York State and afterward ran for President. Another, Henry A. Tilden, joined his father in building up the business. He was chemically and pharmaceutically minded and in 1848 originated and made up the first alcoholic fluidextract ever produced for commercial medicinal purposes. For a long time Tilden supplied practically all the fluidextracts used in the United States, which gave the Company's sales and prestige powerful impetus. About this time Tilden took over and operated until about 1890, a four-pot glass-bottle factory near its present site. Here the first blue bottles in America were blown.

From the beginning, the Company has been under the guidance and management of either the Tilden or the Cox family. J. Harry Cox, a New Yorker, formerly with Hull, Drug Brokers, started working for the Tilden Co. in May 1880, and until his death in Apr. 1942, was in charge of the Company offices. The Company has had only four presidents. Even today a Cox is its president, W. Gordon Cox, son of J. Harry Cox, and another Tilden (Mrs. Samuel J. Tilden West) a vice-president. Its policy has always been well-defined: "Only the finest quality of medications is good enough to fight disease, alleviate pain, and save life." Long before the enactment of the Pure Food & Drugs Act, the Company had set up its own standards of quality.

During the 1880's the Company grew its own hops, celery seed, wild lettuce, dandelion, burdock, motherwort, etc., needed for fluidextracts and other medicinals. Its collectors gathered other crude drug necessities such as corn silk, wild cherry, and pine bark.

It was just about this time that the Company built its own telephone line extending from New Lebanon to Pittsfield, Mass., a vast distance of 12 miles. This was the only telephone in town until 1894, when the Telephone Co. took over, giving Tilden free service to Pittsfield. In 1920 the Public Service Commission decreed that Tilden must pay for its calls to Pittsfield.

The early 1900's saw the expansion of the Company's trade list to include a complete line of over 1,500 elixirs, sirups, tinctures, fluidextracts, tablets, pills, ointments, and other pharmaceuticals.

Henry A. Tilden, one of the early moving spirits in the Company, was not a chemist, but he surrounded himself with competent men: Pierre Kauhape, a French chemist, worked for Tilden for many years and later invented the hard gelatin capsule; another chemist, Prof. H. Dussauce of the Laboratories of the French Government, originated many of the Company's best preparations. However, Tilden was somewhat of a genius in his own right. It was he who first removed the caffeine from coffee and made it into a powder (adding powdered sugar and

powdered milk), which was sold to the U. S. Army during the Civil War. He was among the first in the drug trade to sugar-coat pills and tablets; invented various pharmaceutical stills and tablet machines, which he never patented; and applied the principle of the mimeograph some years before this was invented.

From 1858-61 the Company carried a full stock in a N. Y. City branch at 99 John St.; through 1884, at 175 William St. In 1893 this office was closed and a Western branch established in St. Louis. Manufacturing was carried on there until 1941, when all operations were moved to New Lebanon for greater economy and better control. A full stock is maintained in St. Louis, under manager Horton H. Oliver, for quick distribution to the West and Midwest.

In promoting its products, the Company utilizes the personal approach to the physician via representatives, advertising in ethical publications, and direct mail to the physician. All laboratory and new product procedures are under the supervision of capable chemists and pharmacists.

TITANIUM DIVISION, NATIONAL LEAD COMPANY, in the year 1936 replaced the Titanium Pigment Co., Inc., acquired four years earlier. Titanium Pigment was incorporated in 1916, under the leadership of William F. Meredith, president of the Titanium Alloy Manufacturing Co., to try out on a plant scale L. E. Barton's patented process of manufacturing titanium dioxide pigments. About 1908 Auguste J. Rossi had observed that titanium dioxide had remarkable opacity or hiding power when mixed with oil. In 1912 Barton joined him in the first serious research on the pigment possibilities of titanium dioxide. The new company built a plant at Niagara Falls in 1916, but it was not until 1920 that production began, because power was restricted by the Government to war uses. Since work on titanium pigments was being carried on in Norway concurrently with that of Barton, an agreement was reached between the Titan Co. A/S of Norway and the Titanium Pigment Co. to cross-license patents.

In 1920 the National Lead Co. joined with the Titanium Alloy Manufacturing Co. in developing the Titanium Pigment Co. by purchasing a minority stock ownership in the company, in return for necessary development capital. The collaboration of Dr. Thompson and many other men from National Lead was welcomed. One of the handful of paint chemists who 40 years ago understood the properties of paint pigments, Gustave W. Thompson, early grasped the significance of high refractive index of titanium dioxide and realized that in the proper particle size—2.55 compared with 2.417 for the diamond—titanium dioxide would give hiding power higher than that of any other white pigment in existence.

The board of directors of the Titanium Pigment Co. consisted of William F. Meredith, president; Louis E. Barton and Andrew Thompson, vice-presidents; and from National Lead, E. J. Cornish, Evans McCarty, vice-president (until 1933), Norris B. Gregg, Fletcher W. Rockwell, Gustave W. Thompson, Ashleigh S. Moses (1923), general manager until 1934, and Leonard T. Beale (1929). These men saw in the paint industry the largest outlet for titanium and its compounds, so all efforts were directed toward the development of titanium pigment acceptable to that industry. They knew that the use of established white pigments had become so ingrained a practice among paint men that missionary work would be mandatory. In 1921 genial D. W. (Dan) Edgerly, trained at M.I.T. and thoroughly familiar with the technical and commercial phases of paint, began to introduce the new pigment to the trade. He was assisted by Ivan D. Hagar, another paint chemist.

In 1922 National Lead, having become convinced that titanium dioxide could be developed into a commercial pigment of outstanding quality, agreed to increase

greatly its contribution of capital to the new enterprise. In 1923 a second plant was built at St. Louis, as sales demand since 1921 had exceeded the eight ton-per-day output of the Niagara Falls plant. High costs at Niagara Falls connected with the electric-furnace fusion of ilmenite ore, the need for lower freight rates on raw materials, and a plant to produce blanc fixe of the type required for titanium dioxide-barium sulfate pigment, were the determining factors in locating this plant. Research went hand in hand with the larger production at the new plant and as a result, a process was developed wherein ilmenite ore is reacted with concentrated sulfuric acid and brought into solution without going through an essentially solid phase reaction. This was in contrast to Barton's process in which fusion was carried out with niter cakes in an electric furnace, and the Norwegian process in which a solid cake of ore and sulfuric acid was baked under great mechanical difficulties. Willis F. Washburn, who joined Titanium Pigment in 1921, guided the invention and development of this solution process, known as the Washburn tank process.

Besides financing (and later acquiring) Buckman & Pritchard, Inc., to maintain a supply of ilmenite from beach sands of Florida, the ilmenite sources of the world were investigated under the guidance of Evans McCarty, who was assisted by R. L. Hallett, now chief chemist of National Lead Co., so that a continuing supply was assured.

In 1925, 100 tons of titanium-calcium pigment (30% TiO_2, 70% $CaSO_4$) were produced at the Niagara Falls plant. The result of Barton's earliest work, this pigment had relatively low specific gravity and high hiding power—an ideal combination for flat-wall paints. Samples of it made available to the trade had aroused a real interest. Among the progressive paint companies to evaluate this product was Pittsburgh Plate Glass Co., the pioneer large user of titanium pigments. Improvement in titanium-calcium pigment rapidly followed. By 1928 L. Aagaard and Washburn worked out a method of preparing calcium sulfate anhydrite to replace the gypsum of some of the earlier processes, and as a result this pigment was ready for commercial production.

Concurrently with the growth of the composite pigments Titanox-B and Titanox-C (titanium dioxide-barium sulfate and titanium dioxide-calcium sulfate), intensive research was being carried out on pure or unextended titanium dioxide. The initial development of titanium pigments was in the direction of the composites because these pigments had hiding power equal to that of any pure titanium dioxide which had been produced between 1912-25. As a result of research by Barton and L. W. Ryan, titanium dioxide was finally produced having the hiding power expected of it and at a cost which would be competitive with commercial pigments. By 1929 this pigment, Titanox-A, was being sold at 30¢ per lb. It was not long, however, before pure titanium dioxide having hiding power greater than that of any other white pigment was available in quantity, made by the improved process of Aagaard and Washburn. This pigment of almost universal applicability met demands where extremely high hiding was needed, such as in tin printing inks for containers, white organic enamels for appliances, and other products for which no other white pigment was suitable.

During the period 1920-27, National Lead Co. plowed millions of dollars into the development of titanium pigments, but not until 1928 did the venture show a profit. In 1932 National Lead acquired full ownership of the Titanium Pigment Co. During these 12 years, progress was reflected by the drop in selling price of Titanox-A from $1.50 per lb. in 1920 to 17¢ in 1932; of Titanox-B from 15¢ to 6¢; of Titanox-C from 12¢ (1925) to 6¢. Titanium pigments were sold at a loss when the selling prices were high, but at a profit, when low.

To insure future effective coordination of all activities, Claude F. Garesche' of National Lead Co. was elected a director and vice-president of Titanium Pigment in 1934, when he directed the erection of a new plant at Sayreville, N. J. Completed and in operation in 1935, this plant has grown steadily until today it is the world's largest titanium pigment plant.

Titanium Pigment Co., Inc., was dissolved in 1936 and replaced by National Lead Co., Titanium Division, of which Garesche' became manager. At the same time a new subsidiary, Titanium Pigment Corp., was formed to act as sole sales agents for the pigments produced by the Titanium Division, whose original board of directors consisted of William F. Meredith, Ralph M. Roosevelt, Claude F. Garesche', Louis E. Barton, Leonard T. Beale, William C. Beschorman, Fred M. Carter, Edward J. Cornish, Ivan D. Hagar, Fletcher W. Rockwell, Henry G. Sidford, Gustave W. Thompson, Herman T. Warshow, and Willis F. Washburn.

Since Roosevelt's resignation in 1937, Garesche' has been president of Titanium Pigment Corp. The present board of directors misses the names of Meredith, Beschorman, Cornish, Sidford, and Thompson, who have passed away; and Barton, Carter, and Washburn, who have retired. In addition to those of the first board who are still serving, are: Graham W. Corddry, general sales manager; Durant W. Robertson, vice-president (1938) and general sales engineer; Joseph L. Turner; Charles Y. Pfoutz; Charles Simon; Fehl J. Shirley; and Joseph A. Martino, now president of National Lead Co. Daniel W. Edgerly was elected a vice-president in 1940 and retired in 1945. Hagar was general sales manager until 1941, then assistant manager of the Titanium Division; he has been vice-president of Titanium Pigment Corp. since 1937. Corddry has been general sales manager since 1940 and a director since 1941. Leonard G. Reichhard was elected a director in 1940 and resigned in 1944.

Since its formation, the Titanium Division has carried on in the tradition of the pioneers of the titanium pigment industry. In 1941, realizing that war would mean the cutting off of imported ilmenite, it took immediate steps to provide a source of domestic ilmenite. In Essex County, N. Y., in the heart of the Adirondack Mountains, 11,000 acres were purchased. With the assistance of the Government, Hagar guided the project to production of ilmenite in July 1942. In full operation since 1943, the McIntyre Development, as it is known, provided the raw material for the titanium dioxide pigment vitally needed in the prosecution of the war. Foresight enabled enough imported ore to be stored during the critical period of 1941-42 to keep pigment plants running at full capacity until full production of domestic ore was attained.

The Division owes much of its success to cooperation between departments. An example was the production of rutile-calcium pigment in 1941, based upon the process of F. L. Kingsbury, S. S. Cole, and W. B. Anderson. This pigment, having practically all the opacity of pure zinc sulfide, has become in tonnage the leading white pigment of the paint industry. It was successfully launched through cooperation by research and development headed by Turner, technical director, and Roy Dahlstrom, director of research; sales engineering headed by Robertson; and production guided by Shirley and Pfoutz, now production manager of the Division.

In recent years the chief problem of the Division has been maintenance of the fullest production in the face of an overwhelming demand for its trade-marked Titanox products. Millions of dollars are now being spent to enlarge production at both the St. Louis and Sayreville plants (the Niagara Falls plant was discontinued in 1937). The Division is the world's greatest producer of titanium pigments and among the largest producers of sulfuric acid, which is consumed in its own operations. By-products are sodium sulfide (from blanc fixe manufacture for titanium-

barium pigment), copperas, pyrite cinder, and magnetite from ilmenite-mining operations.

TRENTON CHEMICAL COMPANY was incorporated as Trenton Valley Distillers Corp. under Michigan laws, Nov. 23, 1933. For a few years it manufactured whisky, but soon closed down. In 1942 the Company was reorganized and, in conjunction with Boeckeler Associates, began the manufacture of industrial alcohol. About this time, an intensive research program was instituted, under the direction of A. Keith Kilander, for the purpose of developing other products or by-products. The outstanding result was a new and very effective method of obtaining gluten from wheat. Production on a commercial scale was started in 1943 and has reached 50,000 lb. daily. Gluten is sold to others who use it as a base in the manufacture of glutamic acid and monosodium glutamate. In 1946 wheat sugar sirup was manufactured extensively.

In 1947 the arrangement with Boeckeler Associates was discontinued. On July 25, 1947, the name of the Company was changed to Trenton Chemical Co. Upon the recommendations and sponsorship of Glenn D. Curtis, president, Dr. William J. Hale, vice-president, and Dr. Leo M. Christensen, research consultant, the Company decided to expand and devote its primary efforts to the manufacture of chemicals, and to this end the necessary changes are being made. Vitamins, furfural, and succinic acid will be the next additions to its present products of gluten, poultry feeds, cattle feeds, alcohol, and grain neutral spirits. The Company's plant at Trenton, Mich., a suburb of Detroit, is located on approximately nine acres of land.

The officers of the Company, in addition to Curtis and Hale, are: William M. Hawkins, treasurer; James T. Cox, secretary; and H. Lynn Pierson.

TROJAN POWDER COMPANY had its beginning in the early years of the 20th century as the outgrowth of the invention of its founder, J. B. Bronstein, of a method of manufacturing starch nitrate or nitrostarch, and of his firm belief that better and safer industrial explosives could be made with it. A corporation was organized by Bronstein and his friends and soon thereafter began the manufacture of nonfreezing high explosives containing nitrostarch in place of nitroglycerin, at Seiple, Pa., which is almost the center of the natural cement rock zone of Pennsylvania and New Jersey.

Gradually the "nonfreezing" and "nonheadache" merits of the new explosives began to be recognized and Trojan Powder became well-known and well-liked in the cement rock and flux quarries of the Lehigh Valley and eastern Pennsylvania, which offered the new explosives their first market. Trojan explosives were successfully used in competition with nitroglycerin dynamite in building the Panama Canal. To meet the demands from distant points, a plant was built on San Francisco Bay near Robert, Calif. As the years passed both the Seiple and Robert plants were expanded to keep pace with the constantly expanding uses of Trojan powder.

During World War I the Trojan Powder Co. converted its commercial explosive into a military high explosive and production was undertaken on a vast scale. The Ordnance Department had asked the Company to find some substitute for TNT, to stretch the limited supply. Trojan's Research Department formulated a new explosive which had an efficiency considerably greater than that of TNT, when loaded under similar conditions into grenades of the same type.

The Company was also asked to undertake the loading of Stokes trench mortar shells in addition to hand and rifle grenades. This necessitated expansion of the

Seiple plant which became the largest grenade-loading plant in the country. The Eastern operating company was the Pennsylvania Trojan Powder Co., the Western, the California Trojan Powder Co. Both manufactured all the grenade powder and trench mortar shell explosive used in American grenades and trench mortar shells. They operated until 1920, when they were merged to form the present Trojan Powder Co.

Early in World War I the shortage of acids became apparent. Plants for the manufacture of sulfuric acid, nitric acid, and ammonium nitrate were erected at the Seiple plant. The ammonium nitrate was manufactured by a novel cyclic process which produced a more desirable product for some purposes than the customary graining process. At the close of hostilities, the only country with an adequate and increasing supply of powder was the United States, due not only to the fact that America still had fats for glycerin explosives, but also because Trojan Powder Co. was conserving glycerin by making explosives from starch. Trojan powder was one of the few explosives novelties of World War I, and as such it was placed on the War Department's No. 1 list of preferred war industries.

Postwar the Company's products began to reach nearly every part of the country. Research was continued on a greater scale and the Company began manufacturing fine chemicals for special uses, particularly for primer compositions. Potassium chlorate free from bromates, barium-potassium nitrate, aminoguanidine bicarbonate, and pentaerythritol tetranitrate (PETN) were produced in the required purity. The Company was the first to develop the manufacture in this country of pentaerythritol, used to a large extent in synthetic drying oils, superior resins, varnishes, etc. It also developed a new method for the purification of TNT, millions of pounds of which were salvaged for the Government. This method enabled the Ordnance Department to obtain serviceable TNT from shells that had been stored a long time, during the emergency prior to our entrance into World War II, when our stocks of this material were far too short of preparedness needs.

When we went into World War II, the Trojan Powder Co. was asked to load 20 mm. Oerlikon shells imperatively needed to protect naval vessels. A process was speedily developed and new production begun. Very large numbers of both high-explosive shells and the inert rounds for proof testing and like purposes were loaded at the Seiple plant for both the U. S. Government and for the British. Information on the process was made available to other loading plants which rapidly came into production. Once again Trojan powders were utilized in easing the TNT shortage through the formulation of a demolition explosive as a substitute for the TNT block that had been considered as the basic demolition block. At the request of the War Department, the Company erected extensive facilities at the Seiple plant for both the manufacture of this new explosive and its packaging.

In 1941 the Company supervised the construction and operation (1942) of the Plum Brook Ordnance Works, one of the outstanding government-owned TNT plants. This plant operated until the end of the war, producing enormous quantities of TNT, as well as PETN and Pentolite. The latter explosive was largely used in the highly successful "Monroe effect" hollow charge shell.

With the ending of World War II, Trojan has again turned to the manufacture of explosives for mining, quarrying, logging, stumping, and similar purposes, and of chemicals for use in drying oils, paints, resins, and the like.

UNION CARBIDE AND CARBON CORPORATION was organized in 1917 through the union of five companies—Union Carbide, Electromet, National Carbon, Linde Air Products, and Prest-O-Lite—to establish in production the results of individual researches and developments that might overtax the individual companies. By pooling resources, new ventures could be undertaken with considerably greater confidence. From roots deep in science, in technology, and in engineering came the vigor and fecundity of the united companies. Each had a history of distinguished pioneering. The basic ideas of all the UCC companies are primarily scientific, ideas that can be converted into realistic research, production, and use.

National Carbon processed coke to make carbon products, as well as electrodes for the electric furnaces employed by Union Carbide to make calcium carbide and by Electro Metallurgical to produce alloys and alloying metals. Prest-O-Lite sold acetylene generated from Union Carbide's calcium carbide, and Linde produced oxygen from liquid air to be used with Prest-O-Lite's acetylene in oxyacetylene welding and cutting. Each company had grown up. Each was keyed to quantity production. Sharing skills, imagination, and planning in the new organization was little different from the way these problems had been handled previously. The same persons were involved and the same problems. It was as if, instead of lawyers, the engineers had arranged the final combination, geared directly to production and to cooperative research.

After UCC was formed, Union Carbide continued to produce calcium carbide, and Electro Metallurgical to expand development and production of alloys and metals in the electric furnace. Linde Air Products pursued primarily the Linde process for liquefying air and separating its constituents, and soon applied itself also to the separation of the compounds in natural gas and in the gaseous products from cracking petroleum. Prest-O-Lite produced acetylene and packaged it, dissolved in acetone, in cyclinders. Both Linde and Prest-O-Lite were also interested deeply in the oxyacetylene processes and the equipment of welding and cutting. National Carbon continued to develop various forms of carbon for electric-furnace electrodes, for arc-light electrodes, for many types of dry batteries, and for brushes required in electric motors, dynamos, and other electrical applications.

As these activities developed, the individual enterprises fostered new ones. At the same time, growth required a logical realignment of these activities which created groups that now cut across some of the original junctures of the Corporation, but which are consistent: the Gas Group, comprising activities involved with calcium carbide, acetylene, oxygen, and closely related matters; the Alloys Group, whose metallurgical field is well described by its name; the Carbon Group, engaged with the primary products made of carbon and graphite; the Chemical Group, which grew out of the researches of the original companies; and finally the Plastics Group, developed initially from chemical products and later amplified by the addition, as a Unit, of the pioneer in plastics, the Bakelite Corp.

For all these interests, basic knowledge and persistent research are required. Working with extremes of heat and cold—from 6,000° F. to -300° F.—and with vacuums and great pressures, the Units of Union Carbide and Carbon Corp. now separate or combine nearly one-half of the chemical elements. Into the Units' plants go ores from the earth, petroleum, natural gas, limestone, salt, cotton, coal, and even air—and from them are created hundreds of products ranging from the lightest of gases to the heaviest of metals.

By 1890 Thomas Edison had started the electric light industry and Charles Hall succeeded in producing his new metal, aluminum, by electrolysis in an electric

furnace. However, dynamos and motors were still playthings. The telephone, only 10 years old, was competing lustily against the telegraph. Cities were still struggling with water-gas lighting; and only a few venturesome towns were using the electric arc lights. The automobile remained a "horseless carriage" because the blacksmith was still the master of metalworking. Railroad building was slowing down, and steelmakers were excited about the prospects of building battleships with the improved nickel-chrome armament steels from Germany.

Two of the many people under the spells of electricity and metallurgy were Maj. James T. Morehead of Spray, N. C., late of the Confederate Army; and Charles F. Brush of Cleveland. Morehead had a cotton mill and facilities for electric power from a dam across the Smith River at its confluence with the Dan River. Excess power from that dam eventually led to the Union Carbide Co. Brush's efforts to supply satisfactory carbon electrodes for his new electric arc lights paved the way to National Carbon Co. These two enterprises gave their name to the corporation which developed from these pioneers, even though beyond their scientific spirit there was no relationship at their origin.

Around 1888 Morehead sought a new enterprise to use his excess electric power profitably. He brought to his cotton mill experts who proposed to produce aluminum. With one of these he formed the Willson Aluminum Co. Three vital consequences stemmed from the failure of these attempts to improve upon Hall's aluminum process. First, the earliest commercial electric arc furnace, an achievement that raised by more than 2,000° F. the highest temperatures then obtainable. Second, the discovery, in this furnace, of a method of producing calcium carbide, which easily yields acetylene in the presence of water. Finally, the tremendously valuable industry of alloys produced in electric furnaces by techniques developed from beginnings fostered by Major Morehead.

The calcium carbide supplied at Spray was at first an utterly strange stuff that no one knew how to put to useful work. But Morehead set out with samples and the knowledge that water and his carbide would yield a flammable and potentially useful gas, acetylene. He hoped to interest Northern capitalists in his venture. Seven carbide plants were started as the result of his efforts: one in Scotland, one in Germany, five in the United States. The American plants were at Spray, N. C.; Niagara Falls, N. Y.; Sault Ste. Marie, Mich.; Lockport, N. Y.; and Appleton, Wis. But times were difficult; there were no generators, burners, or other means of consuming acetylene and producing revenue, and of the five American plants only two survived: the Superior Carbide Co. at the Soo, installed by the Peoples Gas, Light & Coke Co. of Chicago, and the Acetylene Light, Heat & Power Co. of Philadelphia, whose plant was at Niagara Falls.

Among the groups Major Morehead interested were some New York and Chicago capitalists who formed the Electro Gas Co. to which he transferred all rights in his carbide, acetylene, and furnace discoveries for light, heat, and power, but retained the "chemical" (which included the metallurgical) rights. Electro Gas Co., in turn, licensed other companies to produce carbide and commercialize acetylene lighting in various territories. One of these was the Peoples Gas, Light & Coke Co. which established the Sault Ste. Marie plant. The gas company in Chicago was making water gas and used crude oil for its enrichment. It hoped to substitute acetylene as an enricher, because the candle power of the water-gas flame could be raised with acetylene far beyond anything possible with oil.

The temporary success of this approach, backed by the production of acetylene from a "continuous" furnace invented at the Soo by W.S. Horry, led the personnel of the gas company and several New York capitalists to form the Union Carbide Co. in 1898 and buy up the parent Electro Gas Co. and its subsidiaries. The same

year they acquired the two-year-old Acetylene Light, Heat & Power Co. plant at Niagara Falls. They then enlarged the carbide plants at the Soo and at Niagara Falls, where the pot-type furnaces were replaced by Horry's rotary furnaces. Several important figures in Peoples Gas who helped form Union Carbide later became connected with Union Carbide and Carbon; C. K. G. Billings, well-known Chicago capitalist; George O. Knapp, who became president of Union Carbide; Anthony N. Brady, director of UCC for many years; C. E. Dietrich, also long a director; and at a somewhat later date J. J. Ricks, director and later president and chairman of the Corporation, who came as part of the law staff of Peoples Gas.

Union Carbide Co. faced from the beginning a threefold problem. It had to produce calcium carbide on a large scale and develop many phases of the use of acetylene. It also faced a problem in working out the equipment to burn acetylene most efficiently. The Company started a farsighted construction program. Contracts were made with the Niagara Falls Power Co. for power on a scale to cover expanding growth in the future, while the Niagara Falls plant was enlarged. To supply the Soo plant, the Lake Superior Power Co. was organized and a generating plant constructed. By 1904 the Niagara and Soo plants were operating with combined capacity sufficient to supply the then-full demand for carbide in the United States. The early market was for ordinary lighting purposes, and generation of acetylene called for entirely new mechanical devices. These had to be invented, tested, and developed. Many people were flooding the market with all kinds, shapes, sizes, and types of acetylene generators, from a self-generating individual lamp to large units for supplying a community. Soon carbide was being sold for miners' lamps; for table and portable lights; for buoys marking channels in bays, harbors, and rivers; and for many large street and farm lighting installations.

For several years Union Carbide struggled to develop safe and efficient generators, cooperating with fire underwriters and public and private bodies to safeguard the generation of acetylene and direct its use within safe limits. About 1905 it fostered the establishment of an apparatus and generator-manufacturing business, Oxweld Acetylene Co., which with other apparatus interests was destined to make acetylene one of the most useful of industrial gases.

Meanwhile, after Major Morehead sold the carbide business, he again turned to the electric-furnace products. His carbide furnaces could smelt many ores. Again he was highly successful, being the first to produce a ferroalloy in an electric furnace. Building our Spanish War battleships was a strong, timely impetus to alloy steel developments. Armor plate was being replaced about 1890 by improved armament steels developed by the Creusot Works in France and later by the Krupps in Germany. These nickel-chrome alloys had either to be imported or produced here by new methods for the ambitious program to modernize the Navy. This provided a reason for the Willson Aluminum Co. to turn to silicon, chromium, and other ingredients of alloy steel when its aluminum process proved impractical. It began to produce high-carbon ferrochrome in its original carbide furnaces and continued to experiment as the business grew.

Carbide and ferroalloys can be made interchangeably in the same furnaces, so it was advantageous for a calcium carbide manufacturer to obtain ferroalloy rights. Union Carbide was thus naturally interested in the improved techniques of Morehead's company and in the ferroalloy business it had developed. Thus, Aug. 29, 1906, Union Carbide took over Willson Aluminum, combined it with some metallurgical interests that had gotten under way at Holcomb Rock, Va., and Glen Ferris, W. Va., where greater water power developments were possible, and formed the Electro Metallurgical Co.

The first and most obvious consideration in this decision was Union Carbide's

desire to acquire the best in electric-furnace design and experience. A second idea was to diversify to assure the most economical utilization of the large blocks of electric power that must be contracted for in such an enterprise. This step also broadened the sales possibilities by having more than a single product to sell. With Electro Metallurgical Co., Union Carbide acquired an important pioneering enterprise with valuable personnel, particularly E. F. Price, who had grown up up with the business and was one of Morehead's original employees. It also acquired Frederick M. Becket and his Niagara Research Laboratories which had explored silicon and ferrosilicon and the possibilities of using this element to reduce refractory ores and recover other metals. Alloys were evidently to be one of the great ingredients of modern economy, giving steel and metals greater strength and new adaptability. And Electromet did build up its products to nearly 50 ferroalloys and metals. Though alloys of chromium, manganese, and silicon have led among these products, Electromet is also a major producer of alloys of tungsten, vanadium, zirconium, columbium, calcium, and boron. Its plant at Alloy, W. Va., started in 1934, is now one of the most impressive electric-furnace installations in the world.

Electromet's growth has been concerned as much with technological research as with production achievements. One of its most brilliant coups was in lowering the carbon content of ferrochrome. A result of Becket's studies of ore reduction with silicon instead of coke, low-carbon ferrochrome was a big impetus to the development of fine stainless steels, in which carbon content must be closely controlled. In early ferrochromes, carbon ran as high as 7%; through Becket's revamping of furnace techniques, Electromet worked it down to .03%. Early pioneering resulted in the first successful production of silicon metal, without which aluminum alloys would lack the toughness which makes them useful for aircraft. When the petroleum industry found the stainless steel of its high-temperature reaction chambers being mysteriously eaten from within, Electromet came up with the discovery that columbium, long just a metallurgical curiosity, would prevent this intergranular corrosion. The many and varied projects from Electromet's research laboratories have done much to broaden the usefulness of metals.

Interest in alloys was broadened after the formation of UCC in 1917. A company that pioneered in resistant alloys was Haynes Stellite Co., formed by Elwood Haynes at Kokomo, Ind. Famous for his inventions in the automotive field, Haynes' immediate object in 1902 was to produce for his automobile shops special tools made from alloys discovered and developed by him. Stellite possesses the remarkable property of "red-hardness," retaining its strength and cutting edge in a machine tool run at a speed that heats it hot enough to draw the temper of any steel tool then available. The new nonferrous alloy revolutionized the machine shops and metalworking industries by greatly increasing the speed and hence reducing the cost of machining operations. It was significantly responsible for the growth of the automobile industry. Haynes Stellite joined UCC in 1920, and cooperative developments soon produced Stellite welding rods for hard-facing metal-wearing parts; then a series of cast tungsten carbide materials providing extreme hardness in oil-well drilling tools. Both were useful tie-ins to Linde's interests in welding. In 1929 further metallurgical cooperation resulted in Hastelloy heat and corrosion-resistant alloys for chemical plant equipment. Using as its raw materials largely the alloys produced by Electromet, Haynes Stellite fitted snugly into the Corporation, finding a comfortable place in the Alloy Group.

U. S. Vanadium Corp. entered Union Carbide and Carbon for opposite reasons; instead of drawing from Electromet, it fed the company. It owned important ore deposits of valuable alloying elements and facilities to beneficiate them, and

originally mined and smelted ore from its own deposits. Later, U. S. Vanadium bought the Standard Chemical Co. of Colorado, formerly sole American producer of radium, which was forced out by the discovery of richer, more readily and cheaply worked deposits in the Belgian Congo. In the carbide picture such domestic ores had an important place, and the Corporation gained additional efficiency by carrying its operations back to the ore, particularly for vanadium, which imparts valuable properties to ferroalloys. Subsequent properties acquired near Pine Creek, Calif., provides United States Vanadium with domestic tungsten ore.

Development of acetylene and particularly of methods and devices for its efficient use, required several other companies. Oxweld Acetylene Co. functioned thus for Union Carbide Co. The Prest-O-Lite Co. and the J. B. Colt Co. were important outsiders before they joined UCC.

The bicycle, later the automobile, created demands for headlamps. Carl Fisher and his partner, Henry Jackson, who operated a bicycle shop in Indianapolis, became interested in this problem. Fisher, with his own money and additional funds invested by an Indianapolis banker, James A. Allison, formed the Prest-O-Lite Co., Inc., to supply acetylene-burning bicycle lamps in 1904. The first bicycle and miners' lights had small, integral, carbide-and-water generators to furnish the acetylene. Later they built a small acetylene generator that could be mounted on the running board of a car. These lights were immensely superior to the coal-oil lamps, but they were mussy and smelly, and automobile drivers gratefully received a cylinder containing acetylene dissolved in acetone. Two French scientists, Claude and Hess, had discovered the solubility of acetylene in acetone, and American rights were purchased by Prest-O-Lite for cylinders holding 50 cu. ft. or less of acetylene. This new system supplied the required light efficiently without any of the attention necessary for the small generators. When incandescent electric lamps became sturdy enough to stand the shaking and jarring of automobile use, and the self-starter called for electric power supply on each car, Prest-O-Lite was well enough established in the acetylene business to move on to the next job. This was the development of the oxyacetylene flame for the new art of welding and cutting that opened important possibilities in the fabrication of metals.

The J. B. Colt Co. had been developing markets for acetylene from a different direction, lighting for farms and isolated places where stationary generators could be readily installed. The company originally made magic lanterns and stereopticons, and acetylene with its powerful light immediately attracted Colt's interest. The independence of such lighting from power plants or gas mains was particularly appealing and led to an important business in rural lighting systems, including all the accessories needed to make each unit self-sufficient.

Employment of acetylene for heating progressed simultaneously but along a still different course. As early as 1895, Henri Le Châtelier, a French chemist, had pointed out the enormously high temperature of the combustion of acetylene with oxygen, but not until 1901 did Edmond Fouché announce the first welding and cutting apparatus utilizing the oxyacetylene flame.

Oxygen was first generated by the familiar potassium chlorate laboratory process, followed later by the Brin barium oxide process, and after 1895 by the electrolysis of water. Prior to 1907 its production was trifling and was confined to the oxyhydrogen limelight for stage lighting, with almost minute quantities used in medical practice.

However, the possiblities of oxyacetylene—heating, welding, and cutting—required lower-cost oxygen for full realization. Hence European-developed liquid air processes for producing pure oxygen from the atmosphere early interested the producers of carbide and acetylene. Carl von Linde, eminent physicist of Munich,

who pioneered the refrigeration industry with the first ammonia compression machine in 1873, made the first successful commercial machine for liquefying air in 1895. He visited Cleveland in 1906 and dined with a personal friend, Myron T. Herrick, and several others from the National Carbon Co. Linde's liquid air process so interested the National Carbon group that they then and there formed a syndicate to acquire American rights, and Jan. 24, 1907, organized the Linde Air Products Co. The first Linde equipment, installed in Buffalo by Cecil Lightfoot of British Oxygen Co., with a monthly capacity of 750,000 cu. ft. oxygen, was followed by a similar installation at East Chicago in 1910 and units of double this capacity at Trafford, Pa., and Elizabeth, N. J.

Although originally formed as a separate enterprise, Linde's relations were extremely close with Union Carbide and Prest-O-Lite. The three worked together with the continuous harmony of common endeavor. The uses of oxyacetylene processes have been greatly extended through the development of new applications, such as the mechanized oxyacetylene conditioning of steel, flame-hardening, flame-softening, and flame-gouging. Several of these new uses would not have been possible without Linde's later development of the Driox and Cascade oxygen systems for successful distribution of liquid oxygen.

National Carbon Co., oldest of the companies, came into being in 1886 practically with the birth of the electrical utility industry. The electrochemical industries were yet to be born; no one had the remotest notion that some day tons upon tons of graphite electrodes would be required. Furthermore, electric dynamos and motors had not yet become universal convertors of electrical and mechanical energy. The telephone was far from the huge consumer of dry cells it is now. Ten years before, the Public Square of Cleveland had been crowded with people who had come to view a new wonder of illumination in a gaslight era, when Charles F. Brush of the Telegraph Supply Co. exhibited the first commercial electric arc light. The demonstration was a short-lived success, but stimulated Brush and his associates to solve the problem of carbons. He found the key literally in his backyard. After searching Europe and America for a suitable material, he discovered that his best raw material was the petroleum coke from the Standard Oil refinery within a mile of the Telegraph Supply Co. plant. For years Standard Oil had been burning this useless by-product carbon residue left after distillation of crude oil. Brush established the first large industrial use of this coke.

To make his own lighting carbons, Brush added a carbon-manufacturing department to his factory and changed its name to the Brush Electric Co., with W. H. Lawrence as superintendent and W. H. Boulton as foreman of the new Carbon Department. Both men later left Brush Electric: Boulton in 1881 to join W. U. Masters in a separate company to manufacture carbons, and Lawrence in 1882 to join them. Four years later Lawrence organized the National Carbon Co. and became its first president. Associated with him as directors were James Parmelee, Myron T. Herrick who combined experience in law and banking, Andrew Squire, and Webb C. Hayes. The success of the new company was almost immediate. The physical weakness and short life of the old electrodes were gradually overcome and the price of lighting carbons dropped to $8 per thousand—less than 10% of the original price.

The technique of making illuminating carbons is similar to producing electrodes for electric furnaces, and improved electric furnaces were largely a question of larger carbon electrodes. Herein lay the community of interest between two UCC companies. Thus when Union Carbide was ready in the 1890's to build its own furnaces for calcium carbide production, National Carbon was prepared to equip them with electrodes. National Carbon continued to progress with carbon elec-

trodes, improving raw materials, and developing extrusion techniques and baking processes to provide electrodes for furnaces making ferroalloys, phosphoric acid, calcium cyanamide, and eventually electric-furnace steels.

It became apparent that higher-capacity electrodes would be more efficient in certain types of furnaces, particularly as anodes for production of chlorine in electrolytic cells. As this market opened, so also grew the Acheson Graphite Co., commercializing the techniques of Dr. Edward G. Acheson for converting carbon into artificial graphite. The basis of the Acheson process is the conversion of baked electrodes from hard, amorphous carbon to soft, greasy graphite by heat treatment at the extraordinary temperatures reached in the electric furnace itself. The change in carbon's properties thus effected is remarkable and extremely useful, especially the changes in its electrical properties and its acquisition of lubricating qualities. Later, in 1928, Acheson Graphite became a unit of UCC and joined the Carbon Group.

National Carbon's expansion into the battery business was a logical application of a technical skill already well developed and several years' further development, based on the original patent to Coleman in 1893, led to the marketing of the Columbia dry cell in 1896. This was one of the first satisfactory mobile sources of electricity, vital to the telephone system of the country. Long before incandescent lighting limited the arc-light market for carbons, the internal combustion engine, particularly, fostered a demand for the newly invented dry cells as sources of electricity for its ignition systems. Actually the need for dry cells, even before the automobile, pushed annual sales past the million mark at the turn of the century. Beyond that, the dry-cell development of the company enabled it, when the self-starter and storage battery met automotive demand, to supply the needs of telephone growth from 1910-25 and at the end of this period to give the ballooning radio industry the many types and sizes of batteries it required.

When Union Carbide and Carbon Corp. was formed in 1917, three of the companies forming the new corporation were engaged upon separate, extensive research programs at the Mellon Institute. The Institute was still quite young when Union Carbide Co. founded an investigation of its electric-furnace techniques and ferroalloys. At about the same time, Linde Air Products initiated an investigation of its own operations and particularly of the minor constituents of air and the techniques of oxyacetylene cutting and welding. Prest-O-Lite was also investigating its principal problems at the Institute. Most important of these investigations was Prest-O-Lite's, to uncover a source for acetylene other than calcium carbide. From that research grew a whole new phase of synthetic organic chemistry based on petroleum and natural gas. After the amalgamation, Linde shifted the major emphasis of its research to the applications of oxygen. This move has now resulted in methods of handling big quantities of liquid oxygen instead of the compressed gas, thus avoiding the large tare weight of the cylinders containing the gas under pressure. Also developed by Linde and destined to become a highly valuable asset of the united companies was the technique of separating gases. This was later applied with outstanding success to the problems of separating and purifying hydrocarbon gases from natural gas and the cracked gases of petroleum refining.

Researches at Mellon Institute for methods of making acetylene without employing calcium carbide, pursued by Prest-O-Lite, and the possible chemical elaboration of acetylene itself, which occupied Union Carbide, revealed broad new fields awaiting chemical exploration and exploitation. Two parts of the field were differentiated: derivatives of acetylene itself and chemical elaboration of natural gas. Most significant was the development of chemical products of petroleum gases, revealing what still seem to be practically limitless possibilities of expansion.

Indeed, its progress has created an entirely new chemical industry of the straight-chain, aliphatic hydrocarbons quite comparable with that previously developed to utilize the cyclic, aromatic hydrocarbons of coal.

Carbide and Carbon Chemicals Corp. was formed in 1920 to develop this new field of aliphatic chemistry. The first product was compressed gas, propane, separated from natural gas by techniques engineered by Linde's H. E. Thompson. As Pyrofax bottled gas, propane was the first of the liquefied petroleum gases to be sold for cooking, heating, and later, refrigeration in suburban and rural areas. Ethylene glycol, a relatively new compound made by others (during World War I) as an intermediate for mustard gas, came as one of the first chemical products. Carbide's production of it from ethylene put it in an entirely new class. Low-freezing dynamites could be made from it readily and now at prices that encouraged expansion of this business. Later ethylene glycol became the basis of anti-freezes and on this application has grown to extraordinary stature.

Most of the compounds made in the earliest days of the new corporation had previously existed, if at all, only in recondite treatises on chemistry. The first samples were prepared at Mellon Institute by Dr. George O. Curme, Jr., and his coworkers there and turned over in four-ounce sample bottles to Linde's James A. Rafferty, who passed them out to everyone who might possibly find a use for them. Naturally, this method of selling was not all-sufficient. Significantly, Rafferty chose a simon-pure organic chemist with a Ph.D., Joseph G. Davidson, as his salesman of the products for which no market existed. This step was in direct violation of sales principles of the time, but is now common practice in chemical companies. The same policy has been followed in the choice of executives so that Carbide and Carbon Chemicals Corp. has been operated by technologists who have learned business administration rather than by business executives who have learned technology.

For acetone, producible by the new techniques from propylene, a market already existed. Nitrocellulose lacquer was coming into its own and found some of Curme's compounds, branded Cellosolve and Carbitol, and their homologs, valuable solvents. On the basis of a contract for these lacquer solvents, the new company moved in 1925 from its first small plant at Clendenin, W. Va., to South Charleston. Later the operation extended to an island in the Kanawha River, and continued to grow far beyond the bounds set by the island plant, with huge new plants producing ethyl alcohol, isopropanol, glycol, and similar large-scale products from petroleum-cracked gases at Whiting, Ind., methanol at Niagara Falls, and other chemical operations utilizing the abundant natural gas of the Texas fields at Texas City. All of these activities are now conducted by CCC, whose output of over 200 synthetic organic chemicals includes: ethylene glycol and a whole series of higher glycols, acetone, acetic anhydride, ethanol, methanol, the amines, ethyl ether and a number of related compounds having important solvent properties, and a great variety of others having values in narrower fields. Three groups of new chemicals have attained a stature never dreamed of. First, the ketones, including acetone, used in ever-increasing quantities in surface coatings based on both nitrocellulose and vinyl resins. Second, the amines, with the ethanolamines, now basic raw materials in soaps, for emulsions such as cosmetics and floor waxes, in many therapeutic agents, and in detergents and similar products. Third, the glycol homologs, which have become tonnage commodities in their roles as aircraft engine coolants, moisture retainers for cigarette tobacco, and extractants for galenicals and flavorings. Added to this are "bread and butter" productions of acetic esters, alcohols, and a host of intermediates, plasticizers, and wetting agents.

While CCC was getting under way, research on reactions of products from

acetylene built up to a point justifying production. Meanwhile other companies had become interested in these possibilities. Canadian Electro Products Co., Ltd., had paralleled CCC's researches with some of its own and a Canadian plant was already in operation. Perth Amboy Chemical Works was interested in similar possibilities, but as a chemical manufacturer with expanding sales outlets, since it did not produce acetylene. These two companies, with Carbide and Carbon Chemicals, in 1924 formed Niacet Chemicals Corp. to carry out certain processes of synthesizing acetaldehyde, acetic acid, and vinyl acetate from acetylene. Other compounds, metal acetates and crotonaldehyde among them, were also produced. The growth of cellulose acetate demanded acetic acid quite beyond the capacity of existing producers by classical methods. Furthermore, rubber vulcanization, accelerators, and anti-aging compounds created outlets for the other compounds producible by Niacet from its basic reactions. Niacet later joined UCC as a division of United States Vanadium Corp.

Vinyl resins, known since 1838, attracted the attention of the Chemical Unit of UCC, which in 1926 began a research program to utilize materials containing the vinyl linkage for the production of synthetic thermoplastic resins. In 1928 these operations were transferred to a pilot plant; in 1936 the first commercial plant was placed in operation; by 1939 the resins, sold under the trade-mark Vinylite, had been successfully used in such diverse applications as linings for beverage cans, flexible sheetings, synthetic fibers, adhesives, and electrical insulation. Paralleling this, CCC's production of methanol from carbon monoxide and hydrogen directed attention toward another fertile field of plastics—the thermosetting resins—since methanol readily yields formaldehyde, essential in several types of such plastics. However, full scope was given to this trend only after the Bakelite Corp. became a Unit of UCC in 1939.

Bakelite Corp. had the same pioneering background that characterized the other Units. Dr. Leo H. Baekeland, the founder, was already an important figure on the American chemical scene through his development of Velox photographic paper and his contributions to the electrolytic chemical industry through the Townsend cell, when between 1906-10 he discovered a method of controlling the reaction between phenols and aldehydes to form synthetic resins. He was seeking a synthetic substitute for shellac, but the product of his researches would neither melt nor dissolve in the ordinary solvents. In a sense, this experience parallels Major Morehead's attempt to make aluminum but actually producing a new, unknown product, calcium carbide. Baekeland, like Morehead, saw the possibilities inherent in his failure and built a success upon what at first seemed a disappointment. For Baekeland found ways to control the reacting mixture so that it could be incorporated in new coatings or be shaped while in a plastic state to yield an infusible, insoluble product, molded in the form desired.

That was the beginning of the phenol-aldehyde resins. In 1922 the General Bakelite Co., formed in 1909 to exploit Dr. Baekeland's inventions, was joined by the Condensite Co. of America and by Redmanol Chemical Products Co., both of which had developed other phases of these resins. The combination became the Bakelite Corp., which in 1939 became a Unit of UCC. Bakelite had continued to explore and develop the various phases of its pioneering, thermosetting resins. Consequently, its addition placed Union Carbide and Carbon Corp., which independently pioneered thermoplastic resins, in practically all applications of synthetic resins of all the principal families. A producers' goods industry in the same way as other UCC Units, Bakelite supplies resins for molding, extrusion, laminating, insulation, and compounding into varnishes, lacquers, and finishes, and for innumerable other purposes. The addition of the Vinylite resins to the Bakelite line put

UCC in a position to meet the needs for a complete variety of synthetic resins and plastics.

The principal Units of Union Carbide and Carbon Corp. in United States and Canada (1947) are: Bakelite Corp., Bakelite Co. (Canada), Ltd., Canadian National Carbon Co., Ltd., Canadian Railroad Service Co., Ltd., Carbide and Carbon Chemicals Corp., Carbide and Carbon Chemicals, Ltd., Carbide and Carbon Realty Co., Inc., Dominion Oxygen Co., Ltd., Electro Metallurgical Co., Electro Metallurgical Co. of Canada, Ltd., Electro Metallurgical Sales Corp., Haynes Stellite Co., Kemet Laboratories Co., Inc., the Linde Air Products Co., Michigan Northern Power Co., National Carbon Co., Inc., Oxweld Railroad Service Co., Prest-O-Lite Co., Prest-O-Lite Co. of Canada, Union Carbide and Carbon Research Laboratories, Inc., and United States Vanadium Corp.

The officers of UCC are: Directors—Ralph R. Browning, George W. Davison, William S. Gray, Jr., Fred H. Haggerson, Homer A. Holt, Paul P. Huffard, John P. McWilliams, Benjamin O'Shea, William J. Priestley, James A. Rafferty, and Edward S. Whitney. Executive committee—Davison, Haggerson, O'Shea, and Rafferty. Executive officers—President, Haggerson; vice-presidents, Rafferty, Browning, Huffard, and Robert W. White; Joseph G. Davidson, Chemicals Division; George O. Curme, Jr., chemical research; Robert J. Hoffman, industrial relations; Stanley B. Kirk, Gases Division; James W. McLaughlin, Plastics Division; Priestley, Alloys Division; John H. Rodger, Railroad Division; H. Earle Thompson, engineering; Arthur V. Wilker, Carbon Division; secretary-treasurer, Morse G. Dial.

UNITED CARBON COMPANY, a Delaware corporation chartered Feb. 19, 1925, merged the business and assets of the following 15 companies: Kosmos Carbon Co., Natural Gas Products Co., Cumberland Carbon Co., Louisiana Carbon Co., Liberty Carbon Co., Central Carbon Co., Standard Carbon Co., Humphreys Carbon Co., Pelican Gas & Carbon Co., Green River Carbon Co., United Oil & Natural Gas Products Corp., Consolidated Carbon Corp., Louisiana Gas Products Corp., Tampico Gas Co., and Fred Stovall. The manufacture of carbon black in the United States began prior to 1880 and continued to be a small industry furnishing pigment for black inks and paints until 1914, when carbon black's property of reinforcing and strengthening rubber goods, especially rubber tires, was discovered. Since then the growth of the industry has been geared to the growth of the automotive and tire industries, with the result that approximately 95% of all carbon black goes into rubber goods.

In 1914-18, about 25 new carbon companies were organized, the more important being Kosmos Carbon Co. and affiliated companies, controlled by Oscar Nelson of Charleston, W. Va., and T. A. Whelan and T. F. Koblegard of Weston, W. Va.; and Liberty Carbon Co. and Louisiana Carbon Co., organized by G. Alvin Williams of Clarksburg, W. Va. When the aftermath of World War I brought falling and disorderly markets, with prices below costs, Nelson, Williams, Whelan, and Koblegard decided to pool their resources in the United Carbon Co. Nelson, formerly general manager of Columbian Carbon and later president of Kosmos Carbon, was chosen general manager, with the title of vice-president for about six months and thereafter as president, which he is today. Williams became 1st vice-president, which he held to his death in 1943.

The original capital structure of the Company consisted of $2,500,000 of 7% six-year first mortgage bonds; 54,831 shares of 7% noncumulative preferred stock, par value $100; and 217,300 shares of voting common stock, no-par value. The proceeds from these were given to the various constituent companies in payment

for assets received. The last of the bonds were called for redemption Oct. 1, 1929, the preferred stock, July 2, 1934. This was made possible through earnings and expansion of working capital by the sale of 181,270 common shares to stockholders in 1929 at $50 per share, which netted the Company approximately $900,000.

Originally, United Carbon had no subsidiaries. Its operations were chiefly in the manufacture of carbon black and the sale of natural gas. Soon after organization, however, carbon plants in West Virginia and Kentucky found it more profitable to migrate to Monroe, La., gas field, where large supplies of cheap gas were available, thus permitting the gas which had formerly supplied the plants in West Virginia and Kentucky to be sold to pipe line companies at substantially higher prices. With the discovery of vast quantities of sour (sulfur-contaminated) gas in the Texas Panhandle, beginning in 1927, the migration of carbon plants to that field began. United Carbon participated in this migration by establishing manufacturing subsidiaries there, Kosmos Carbon Co. and Eastern Carbon Black Co. It continued to be an operating company, producing and selling natural gas in West Virginia and Kentucky, and operating carbon plants in Louisiana.

In 1928 the Monroe gas field became the focus of major pipe lines transporting gas to New Orleans, Shreveport, Memphis, Birmingham, Atlanta, and St. Louis. United Carbon elected to become one of the major suppliers for these pipe lines, with the result that during the next five years its carbon black operations in the Monroe field shrank to a single small plant, with the remainder of its manufacturing capacity concentrated in the Texas Panhandle. In 1934 carbon black manufacturing facilities were expanded by purchase of Texas Carbon Industries, Inc., with four carbon plants in Texas and Oklahoma. In the spring of 1935 a plan of segregating all carbon black manufacturing operations in a single subsidiary was carried out with the formation of United Carbon Co., Inc., now United Carbon Co., Inc., (Maryland). United Carbon Co. thus became a holding company in the field of carbon black manufacturing and an operating company in the field of natural gas and oil production. However, with the acquisition of a controlling interest in Combined Carbon Co. in the fall of 1935, and in Reliance Carbon Co., Inc., in 1936 (the majority shares of these companies being held by United Carbon Co., Inc.,), new subsidiaries came into existence. Through the acquisition of minority interests, United Carbon Co., Inc., eventually became the sole owner of Combined and Reliance, and the latter company was dissolved in 1942. At the present time there are no minority interests outstanding in the shares of any of the United Carbon group except a nominal interest in one very small gas company operating in West Virginia, United Gas Co.

In 1928 United Producing Co., Inc., a wholly owned subsidiary, was organized in Louisiana to acquire mineral royalty interests. It was reincorporated in Maryland in 1935, and has since been used as the vehicle for the development of oil and natural gas on a considerable scale. This company was a pioneer in the development of the Johnsonville oil pool in Wayne County, Ill., beginning in 1941, and in the Bonnie View field of Refugio County, Tex., beginning in 1944. It is now a major gas producer in the Wyoming field of West Virginia and in the Hugoton field of Kansas.

The outstanding capitalization, as of Dec. 31, 1946, consisted of 397,885 shares of common stock. On Feb. 28, 1947, the board of directors voted to split the stock two for one to stockholders on record as of May 1, 1947. The total outstanding stock after that date will be 795,770 shares.

The Company is a member of Carbon Black Export, Inc., and is represented in London by Chance & Hunt (Imperial Chemical Industries, Ltd.) and in Manchester by Anchor Chemical Co., Ltd. Sales in Canada are handled through

Canadian Industries, Ltd., Montreal and Toronto, and in Mexico through Ernesto del Valle and Colores, S. de R. L. of Mexico City. Domestic representatives are General Supply & Chemical Co., Trenton; Frank H. Topp, Louisville; Thompson-Hayward Chemical Co., Kansas City and St. Louis; L. H. Butcher Co., San Francisco and Los Angeles; R. W. Greeff & Co., Inc., New York. Branch offices are located in Borger and Corpus Christi, Tex.; Monroe, La.; Satanta, Kans.; Sayre, Okla.; Pikeville, Ky.; Cisne, Ill.; and Brenton, W. Va. The Company's own sales offices are in Boston, New York, Akron, and Chicago; the headquarters, in Charleston, W. Va.

U. S. INDUSTRIAL CHEMICALS, INC., was organized to serve industrial users of one chemical—C_2H_5OH—three months after the Denatured Alcohol Act freed industrial alcohol from taxes applied to beverage spirits. The original company, U. S. Industrial Alcohol Co., was incorporated Oct. 17, 1906. The new law went into effect Jan. 1, 1907. It was not necessary for USI to build any industrial alcohol plants, since its requirements were met by production facilities at registered distilleries operated by wholly owned subsidiaries acquired when the Company was organized.

Industrial alcohol from molasses was made by a plant in Brooklyn, N. Y. (operated by Columbus Distilling Co.) and two in New Orleans (operated by International Distilling Co. and Louisiana Distillery Co.). Alcohol from grain was made at an inland plant in Peoria, Ill. As wood alcohol was the most used denaturant, another subsidiary brought into the USI orbit in 1906 was the Wood Products Co., Buffalo, N. Y., which produced and sold refined wood alcohol, acetone, and methyl acetone.

Funds for these acquisitions and operations were provided by issuing 60,000 shares of 7% cumulative preferred stock and 120,000 of common stock, amounting to $18,000,000, which were listed on the N. Y. Stock Exchange on Apr. 12, 1911. The preferred stock was retired in 1928. The amount of stock has been increased several times, the latest in July 1946, when the number of no-par common shares was increased from 500,000 to 1,000,000. The Company's net worth today is approximately $30,000,000.

In the early days the subsidiary companies not only provided production facilities, but sales organizations and considerable chemical processing technology. To guide the parent company's activities, the founders picked for general manager, Frederic M. Harrison, president of James A. Webb & Son, Inc., largest distributors of industrial alcohol in the United States. He was elected president of USI in 1909 and for 13 years, from offices located at 27 William St., N. Y. City, directed the Company's affairs—a period which covered most of the alcohol phase and the beginning of the chemical phase of USI's history.

One of the Company's first acts of commercial importance was to trade-mark its brand of completely denatured alcohol, Pyro, Mar. 1907, which it was hoped would rival kerosene as a fuel. The Alcohol Utilities Co., operating in New York and New Orleans, was formed to distribute fuel-using "gadgets," and USI's first advertising campaign was launched in 1908, offering to deliver to any part of the United States one alcohol lamp complete and two gallons of Pyro. Pyro alcohol as a liquid fuel was a disappointment and the Utilities Co. was eventually dropped. But the venture proved worthwhile in that it gained a favorable freight-rate classification which was useful a few years later when Pyro became a leading antifreeze, carbon remover, and engine cleaner on the market.

When Congress recognized in 1906 the distinction between the chemical, ethyl alcohol, and alcoholic beverages, industrial alcohol was on its own. This action

was largely the result of an energetic educational campaign conducted by a committee of hatmakers, furniture and electric-apparatus producers, hardware, piano, and chemical manufacturers. Requirements of these and other users were provided by some dozen and a half formulas. But as time went on new uses for denatured alcohol were revealed. Its applications in the production of ethyl acetate, other ethyl esters, vinegar, collodion, chloroform, motor fuel, toilet preparations, pharmaceuticals, medical preparations, and rubbing alcohol were directly the result of USI's efforts in the laboratory and in the field.

One of the first to recognize the value to industry of tax-free ethyl alcohol was a young lawyer, James P. McGovern, who was one of the charter members of USI. He was secretary of the Company, Jan. 1907-Mar. 1918; treasurer, Feb. 1910-Mar. 1915; vice-president, Mar. 1915-Mar. 1917. In 1917 he became "general attorney." Joseph P. Malone, his assistant, followed him as secretary when McGovern joined the Army. In the 18th Amendment establishing national Prohibition, the true character and value of alcohol, the chemical, was recognized in Title III of the Act, largely as the result of the wholehearted cooperation of McGovern. As the complicated laws, rules, and regulations relating to the manufacture, distribution, sale, and use of industrial alcohol grew enormously, McGovern eventually devoted himself exclusively to these matters for USI. In 1928 he also became general counsel of the Industrial Alcohol Institute, Inc., a trade association of industrial alcohol manufacturers. Five years later the Institute asked McGovern to represent the industrial alcohol industry as a whole, which he did until the Institute was dissolved in 1940.

USI enjoyed a large portion of the rapidly expanding industrial alcohol business, which jumped from 1,800,000 gal. in 1907 to 10,400,000 gal. in 1914. The next year, war demands dwarfed this figure, USI alone producing 11,000,000 gal. Part of this increased production came from a plant in Cambridge, Mass., operated by the Purity Distilling Co., a wholly owned subsidiary.

In 1915 construction of the largest and most modern industrial alcohol plant in the world was started in Curtis Bay, Baltimore. By 1916, when this plant began operations, the Company's 1915 production was doubled, and USI became the leading industrial alcohol producer in the country. Equipment was fabricated and erected by Ansonia Copper & Iron Works, a wholly owned subsidiary whose main shop was in Cincinnati. A branch was opened at the Curtis Bay site to do the job on the new alcohol plant. This was reorganized in 1918 as the Curtis Bay Copper & Iron Works, Inc., a subsidiary with larger facilities. Both metalworks eventually proved too much out of the Company's line. Ansonia was sold in 1926 to Buchert Bros., its operators during USI's ownership, and the Curtis Bay company was disbanded, its buildings and equipment becoming part of the alcohol plant.

The alcohol production phase of USI included three disasters. A fire in 1915 wiped out the International plant, which was later rebuilt. In 1919 sabotage and fire ruined the Cambridge and Brooklyn plants, which were abandoned. Additional production units were added in 1926: one in Newark, N. J., to offset the burned-out Brooklyn plant, and one in Anaheim, Calif., to provide facilities on the West Coast. Around this time it was decided to dismantle the Louisiana plant; another plant in New Orleans, the Central (acquired in 1915), was closed; and production in New Orleans was concentrated at International. In 1929 USI purchased Kentucky Alcohol Corp. which had a large plant in Westwego, La. This was operated until 1936 when it, too, was dismantled and most of its equipment used in other USI plants. Molasses and storage facilities continued to be used, however. From time to time, all existing plants have been modernized and improved.

In 1941 ground was broken for a combined denaturing-bonded warehouse-

shipping plant at Chicago, strategically located, with an all-water route from New Orleans. USI was the first to use inexpensive barge shipment of alcohol and chemicals between New Orleans and Chicago. An alcohol-producing plant purchased in Yonkers, N. Y., to supplement production facilities during the war, was sold in 1946. Today, industrial alcohol plants operate 24 hours a day and 365 days a year. This was not the case prior to 1919. Leon Pfeifer, dean of the industrial alcohol business in Louisiana since 1903, and with USI since 1906, was responsible for bringing about the change. Ever since, the extra 52 alcohol-producing days each year have materially aided economic production and increased volume, not only of alcohol, but also of alcohol-derived chemicals and by-products.

During the expansion period in the alcohol phase of the Company's history, several companies were acquired which aided in securing and distributing raw material for industrial alcohol. Two of historical and lasting importance were: James A. Webb & Son, Inc., in 1915, and Cuba Distilling Co. in 1917. Dating back to 1835, Webb was an outgrowth of a "mammoth establishment" known as Webb's Emporium of Light because it specialized in "burning fluids," a combination of four or five parts alcohol to one of rectified spirits of turpentine. When kerosene replaced "burning fluids," Webb became interested in the production and sale of industrial alcohol and by the early 1900's the firm was the largest sales organization in its line in the world. The ties between USI and Webb had always been close. Webb handled most of the pure alcohol and cologne spirits made at the Columbus plant. F. M. Harrison, USI's president, was also president of Webb at the time of acquisition. With Webb, USI acquired a seasoned sales force and the pure alcohol business of practically every hospital between the Mississippi and the Atlantic. The reputation of Webb's alcohol was so entrenched in the minds of purchasers that the Webb division functioned on its own until 1938 and the brand continued to be marketed as late as 1943.

USI's purchase of Cuba Distilling Co., with main offices in New York, and its Puerto Rican subsidiary, got for it molasses-collecting terminals in the West Indies and ocean-going tankers to bring molasses, the main raw material for USI's alcohol, to plants on the mainland. Today molasses also provides such chemicals as butanol, acetone, and glycerin, yet if a small, active group of men had not met in Brooklyn at the turn of the century, the development of these and other products from fermentation might have been delayed for many years. In 1902 this group formed the Columbus Distilling Co. and bought a plant in Brooklyn, N. Y., where manufacture of molasses alcohol was started in a small way. The leading spirit was Nelson B. Mayer, a chemist, who became general manager and later an officer of Columbus; H. M. J. Cardeza was president. Back in the early 1900's manufacturers who used cologne spirits were reluctant to switch to molasses ethyl alcohol, claiming it had a molasses-like odor. But as a result of Columbus Distilling's intensive educational work, molasses alcohol was gradually accepted, even by the perfumers and drug houses.

The feasibilty of making good-quality industrial alcohol from molasses having been proved, the Cuba Distilling Co. was formed in the United States in 1907, to assist the Cubans in disposing of their blackstrap, which was being dumped by the sugar refineries into any near-by stream or river, until stopped by Cuban prohibitive sanitary laws. Its president was José Miguel Tarafa, a Cuban, its vice-president, H. M. J. Cardeza, head of Columbus Distilling. Offices were opened in Cuba and New York. Cuba Distilling Co. chartered a converted steam tanker, the *Carrabee,* to bring molasses from its terminal at Matanzas, Cuba, to the Columbus plant, proving the economy and practicability of steamship transportation. Dr. Mayer went to Cuba early in 1908 to lend assistance in loading the molasses which

gummed the pipe lines. Horatio S. Rubens, an American engineer who managed a sugar mill owned by Tarafa was in on the conference. He suggested installing pumps and followed this up by other useful ideas which made loading of molasses boats more rapid. Dr. Mayer was so impressed by Rubens that he induced Colonel Tarafa to hire him as Cuban manager. Soon Cuba Distilling purchased other terminals at Regla, Guantanamo, and Cienfuegos, tankcars and lighters, and acquired a fleet of tankers. Meanwhile Dr. Mayer had become president of Cuba Distilling and was succeeded by Rubens in 1915.

USI's interest in the Cuba Distilling Co. was a natural one. All but one of its plants were located on tidewater which made molasses a most economical raw material for industrial alcohol. The one inland plant made alcohol from corn which was an expensive raw material better suited to the beverage spirits industry. As the need for industrial alcohol in the United States zoomed, other producers were attracted to the field. Since USI had been buying its molasses from Cuba Distilling, it decided in 1915 to buy that company. By 1917 the purchase was completed. (Later a terminal, facilities, and boats were acquired in the Dominican Republic and a subsidiary was established to handle operations there.) Rubens was elected chairman of the board in 1917, a post he held until 1926. He was also elected chairman of the board of directors of USI and in 1922, when F. M. Harrison retired, to the presidency. In 1927 Charles E. Adams became chairman of the board. Gilbert E. Rubens was president of Cuba Distilling Co. from 1917 to 1927 when he was succeeded by Russell R. Brown. In 1931 Charles S. Munson became president, followed by J. Tenney Mason in 1942 and Paul H. Holstein in 1945. Mason was elected chairman of the board in 1948.

Two developments of long-range significance for USI began under Harrison: establishment of aggressive company-wide Research and Sales Departments. Originally sales were handled through subsidiary companies, and through distributors and agents in strategically located cities. Among these agents was F. W. Thurston Co. of Chicago, distributors for the Wood Products Co., acquired by USI in 1906. Henry I. Peffer, Thurston's vice-president and general manager, joined USI in Jan. 1919 as Western manager, and opened its first directly controlled sales division in Chicago. At that time Edward D. Smythe was sales manager in New York. In 1921 Glenn L. Haskell became USI's Western sales manager, with headquarters in Chicago, and the U. S. Industrial Alcohol Sales Co., Inc., was formed to supervise all alcohol sales activities. When Harrison and Smythe resigned in 1922, Peffer and Haskell were brought to New York as vice-president and general sales manager, respectively. Upon Peffer's resignation two years later, Haskell became president of the Sales Company. The present vice-president in charge of sales, Lee A. Keane, is also a graduate of the Chicago "school."

Today USI's sales divisions are located in Baltimore, Boston, Chicago, Cleveland, Detroit, Kansas City, Los Angeles, Louisville, New Orleans, New York, Philadelphia, and St. Louis. Sales offices under these divisions are maintained in other leading industrial centers. All products of the Company are handled by them. Chicago, however, remains unique as a stepping stone to positions of management in the Company.

The formation of a centralized Sales Department coincided accidentally with the ratification of the 18th Amendment. When Prohibition went into effect, USI's laboratory was busy working out tax-free denatured alcohol formulas for use in rubbing alcohol and tincture of iodine. Its experience indicated that other formulas were possible in which the denaturants would be the normal constituent of the finished product. Accordingly, Harrison went to St. Louis to a leading pharmaceutical house to confer on a specially denatured alcohol formula which would save

the tax on pure alcohol and yet meet the high standards required by its famous mouthwash. The result was S. D. 37, which was soon followed by several other formulas of value in manufacturing antiseptics, mouthwashes, external pharmaceuticals, and many toiletries.

USI today provides a training program for its salesmen in Company laboratories and plants and conducts periodic sales conferences and refresher courses. Sales development is actively participated in by technical specialists and specialized department heads.

When the British demand for acetone for the high explosive cordite in 1915 precipitated USI's entry into the chemical manufacturing field, it opened the door to a research program along modern lines. Jointly with the Hercules Powder Co., USI formed the Curtis Bay Chemical Co., and a plant was constructed at Fairfield, on the outskirts of Baltimore, to synthesize acetone by a new commercial process. This consisted of converting ethyl alcohol to acetic acid by the so-called quick vinegar process. The dilute acetic acid was then neutralized with lime to produce calcium acetate which, in turn, was retorted into acetone. Production of acetone by this method was begun early in 1916 and was continued until Aug. 1919. During that time 15,000,000 lb. were supplied to the British, and 7,200,000 lb. to the U. S. Government.

USI became interested in finding other uses for its large supply of C_2H_5OH. Accordingly, in 1916, a Research Department, headed by Milton C. Whitaker, was established on the grounds of the Curtis Bay Chemical Co. Next year this company went out of existence. Hercules' interests were taken over by USI and a new corporation, U. S. Industrial Chemical Co., Inc., with Dr. Whitaker as president, assumed acetone operations at Fairfield. By the end of 1917, however, with the development of more economical processes and substitutes, acetone production was discontinued, but not the chemical company.

Dr. Whitaker saw in the increasing application of nitrocellulose-type lacquers in the automobile industry an opportunity to use the Company's large productive capacity for acetic acid to make ethyl acetate and butyl acetate, two excellent nitrocellulose solvents. The Research Department and one of its chemists, Arthur A. Backus, during 1917-18 worked out a continuous process for making ethyl acetate from vinegar and ethyl alcohol. Large-scale production was started in 1919. Even today USI's ethyl and butyl acetate are made by an adaptation of the so-called Backus process. Many of the other chemicals, solvents, and by-products produced by USI are adaptations or directly the result of research carried on by the original group during 1916-25. And a number of the men who have held and now hold positions of responsibility started with USI in the laboratory during those years. Dr. Whitaker was vice-president of the parent company, 1917-27, when he resigned to join another chemical company; Arthur A. Backus became vice-president in charge of production in 1928; and after the tragic accident that resulted in his death, he was succeeded in 1942 by Ward O. Griffen. The Company's Engineering Department, which now functions independently under John Bohnlofink, also started in the laboratory.

Among the first chemicals added in quick succession were: methyl acetate, amyl acetate, refined fusel oil, ether, ethylene, isopropyl alcohol, benzene, potassium iodide, ammonium sulfate, diethyl oxalate, and ethyl lactate. USI pioneered the development of adequate domestic supplies of a number of alcohol-derived chemicals formerly available only from foreign sources. Ethyl acetoacetate, first produced commercially in this country in 1923, was followed by acetoacetanilide and other acetoacetarylides, ethyl sodium oxalacetate, ethyl chloroformate, and urethane. Diethyl carbonate was developed in this country from test tube to commercial

quantities by USI which also began manufacturing dibutyl and diethyl phthalates, was responsible for the introduction of diamyl phthalate, and evolved processes for ethylene oxide and ethylene glycol.

In the search for chemicals derived from ethanol, new uses and improved production methods for ethyl alcohol itself were not overlooked. One of the first products developed was a motor fuel containing alcohol, called Alcogas. A Baltimore service station made the initial sales of Alcogas in 1919. The formula was improved a couple of years later by the use of anhydrous alcohol. The Bureau of Standards approved it and the Navy's Aeronautical Engine Laboratory recommended it to its Bureau of Steam Engineering. USI successfully introduced Alcogas in France, England, and Italy. When the price of gasoline dropped to 9¢ a gallon, the market for Alcogas dwindled and USI discontinued making the product. Later development of better gasoline at relatively low prices also made Alcogas uneconomical.

The knowledge that the injection of alcohol-water detonation mixtures in internal combustion engines suppresses detonation and increases engine efficiency was put to use in 1937 when a firm marketed a mechanical device for injecting such a mixture. USI made up a new special formula, Vitol, to be used with this device. Many a flier escaped being shot down by Axis pilots during World War II by injecting an alcohol-water mixture into his plane's fuel. Anhydrous ethyl alcohol was itself an outstanding achievement of USI's research staff, which developed a successful, low-cost continuous process. The first large-scale commercial unit to make absolute alcohol was installed at the Curtis Bay plant early in 1922.

Not the least of USI's early problems was the disposal of the residue molasses stillage left from alcohol production. A way was found to utilize the stillage by making crude potash, known as "vegetable potash" or "Baltimore potash," during World War I. William W. Haughey was employed to coordinate its production and sales. Following the Armistice, USI had to continue making potash of which over 40,000 tons accumulated on plant grounds in Baltimore. One of Glenn Haskell's first problems as sales manager of all USI products in 1922, was to help get rid of this potash. Three large-volume, trade-marked products were developed which are prominent in today's sales: Vacatone, Curbay B-G, and Special Liquid Curbay. Their largest use is in the animal and poultry feed industry where their food value and vitamin content is especially helpful.

In 1920 recovery of by-product carbon dioxide from fermentation gases was begun at Curtis Bay. One of the new type charcoals that had been satisfactorily tested during World War I to remove poisonous gases from the air was found capable of absorbing odorous contaminants from fermentation CO_2. A small-scale plant for purification of about 3,000 lb. of CO_2 daily was put in operation. Today both liquid and solid (dry ice) forms of CO_2 are recovered in large quantities with improved processes at the Anaheim, New Orleans, Baltimore, and Newark plants. The entire production goes to Pure Carbonic, Inc.

To make the utilization of molasses complete, USI developed a method for the direct recovery of glycerin produced in the fermentation. Howard M. Hodge and others, working under the direction of Frank M. Hildebrandt, modified the alcoholic fermentation so as to increase, at the expense of the alcohol, the amount of glycerin produced and to give a residue suitable for use in fertilizers. A new type of yeast was isolated especially adapted to the process.

In 1931 significant changes in the management of the parent company occurred. Charles E. Adams was selected chairman of the board; Charles S. Munson, president; and Glenn L. Haskell, vice-president in charge of all sales since 1927, be-

came first vice-president. With diversification the goal, USI started an energetic program along the lines of acquisition and intensified research.

In 1938 the Company entered the resin field by the acquisition of Robert Rauh, Inc., Newark, N. J., manufacturers of synthetic resins, and Stroock & Wittenberg Corp., importers of natural resins and sellers of both the natural and synthetic product. Because outlets for resins were substantially those for USI's solvents and chemicals, this acquisition was a logical step. Rauh had been formed in 1849 in Germany by David Rauh to make brewer's pitch. About 1912 the business was transferred to the United States and a plant opened in Newark. With the advent of Prohibition, Rauh concentrated on making ester gum, later adding other hard and soft resins. USI erected an up-to-date resin development laboratory in Newark and launched an intensive research program. It built separate modern plants in Pensacola, Fla., and adjacent to USI's alcohol plant in Newark. Additional capacity is currently being provided in Newark and Baltimore. The resin business of USI was conducted under the name of Stroock & Wittenberg until 1943, when the final simplification of the Company's corporate setup resulted in one organization—U. S. Industrial Chemicals, Inc. Only the Cuba Distilling group continued to operate independently. Glenn L. Haskell, who had been elected executive vice-president of the parent company the year before, was elected president of U. S. Industrial Chemicals, Inc.

As a rule, USI has always interested itself in bulk chemicals for industry. One exception is Super Pyro. Another specialty product is Sterno, a patented canned fuel using a nitrocotton gel and alcohol. USI is its sole producer and has owned a substantial interest in the marketing company, Sterno Corp., for many years. USI acquired manufacturing and sales rights to PiB, an insulation and waterproofing compound for automobile and marine electrical systems and electric motors of all kinds, in Apr. 1945, and later purchased the formula and trade name. It has also developed two specialties for the drug manufacturers: Noval ketone, which materially increased production of Atabrine; and methionine, successfully synthesized commercially for the first time in 1946 and selling for less than $10 a pound instead of the previous $400.

In June 1945, USI acquired Dodge & Olcott Co., the oldest and one of the largest firms in essential oil, flavoring, aromatic chemical, insecticide, and related fields. D & O has a factory in Bayonne, N. J.; laboratories in Bayonne and Baltimore; sales offices and warehouses in Boston, Chicago, Philadelphia, St. Louis, and Los Angeles; and foreign representation in Europe, Australia, New Zealand, and Latin America. The Dodge and Olcott families, owners of most of the D & O stock, received USI stock in exchange for their holdings: USI acquired the diversified products it sought. Both companies have had an interest in the insecticide field. Since 1937 USI had marketed a chemical insect repellent trade-named Indalone. D & O had done considerable work on pyrethrum and rotenone, and worked out a new technique for making a previously unavailable purified pyrethrum extract. During the recent war this led to the amazing military aerosol program. For a year or more after 1942, D & O was the only source of this purer, more concentrated pyrethrum.

USI has established one of the most modern and well-equipped entomological laboratories in the country, at Fairfield, Baltimore, to further studies in the insecticide and insectifuge field. A recent development was an entirely new series of synthetic organic chemicals, the piperonyls, which are proving extraordinarily effective as insect-control materials.

D & O's origins go back to a wholesale druggist and importer of chemicals and essential oils for food and pharmaceuticals—Robert Bach, an Englishman—who

opened shop in New York in 1798. A grandfather of Francis T. Dodge, D & O's president since 1926, became a partner in 1840; the first Olcott became a partner in 1859. The late Francis Despard Dodge, cousin of D & O's president, is noted for his isolation, in 1889, of citronellol and its distinction from the allied citronellal. Under Dr. Dodge, for many years D & O's chief chemist, the laboratory at Bayonne expanded from the mere testing and purification of essential oils to the manufacture of aromatics, flavors, and perfume bases. In 1923 Charles A. Myers took charge of production, and under his supervision the various Bayonne operations were welded into a modern, efficient plant. Myers was made vice-president in 1938 and executive vice-president in 1946.

Upon its acquisition, the Dodge & Olcott Co. became Dodge & Olcott, Inc. For closer cooperation, three officers of USI, Charles E. Adams, Glenn L. Haskell, and Bracebridge H. Young, were elected to D & O's board of directors; Francis T. Dodge, became a director of USI.

USI's first laboratory was erected in a cow pasture near the chemical plant in Fairfield, Baltimore, in 1916. It was enlarged in 1920 and for more than a decade was the center of USI's research and development. In 1932 organic research was moved to Stamford, Conn.

A fermentation research and development laboratory was built in 1924 on the grounds of the Curtis Bay plant in Baltimore. Alcohol and chemicals from molasses, grain, potatoes, and other fermentable materials are developed here. One of the outstanding achievements of this laboratory was the production of butyl alcohol and acetone from fermentation of molasses. Five years elapsed (1930-35) before a successful process was developed. Since 1940, Frank M. Hildebrandt, USI's chief bacteriologist, has been director of the laboratory.

In 1943 resin research was expanded and a new, modern laboratory located in Newark, under the direction of Kenneth A. Earhart, where development of alkyd, phenolic, maleic, and related resins for coatings is continuing. Also since 1943, technical and sales development work has been coordinated into special departments which develop new uses for existing products, furnish technical field service, and study competitive products and industrial trends.

To enable these departments to function more adequately and to intensify entomological research under Walter E. Dove, director, a new technical development laboratory was established in 1946 at Fairfield. Its purposes are product testing and evaluation of USI's solvents, chemicals, and proprietaries, as well as insecticides and insectifuges, and competitive products. In addition, process development and applied research are conducted on insecticides, insectifuges, anti-freeze, and dye intermediates. One group at the laboratory handles chemicals and solvents sales problems requiring laboratory work. A modern pilot plant takes care of chemical, resin, fermentation, and insecticide problems which have advanced beyond the laboratory stage. In 1948, in order to consolidate this expanded research and development program, activities were concentrated at Baltimore where additional modern facilities were installed. These laboratories, under direction of Frank M. Hildebrandt, are concerned with all the Company's products.

From time to time USI has undertaken research projects at universities, mostly pertaining to fermentation problems and animal feed ingredients reclaimed from stillage. Nutrition experiments were carried out at Cornell University on poultry and dairy feeds, and later, extensive poultry feeding tests at the University of Maryland, which are still in progress. At Cornell fermentation research has been concentrated on obtaining new strains of yeasts with improved characteristics for commercial production. The physiology of certain fermentations of interest to the Company has been studied at Cornell and production has benefited consider-

ably therefrom. Coordination of USI's existing research and development program and future direction rests in the hands of Lawrence W. Bass.

Directing USI activities are officers practically all of whom have come up from the ranks: Charles E. Adams, chairman of the board; Glenn L. Haskell, vice-chairman of the board; Charles S. Munson, chairman of the executive committee; William P. Marsh, Jr., president; J. Tenney Mason, vice-president; Ward O. Griffen, vice-president of production; Lee A. Keane, vice-president of sales; Bracebridge H. Young, vice-president and secretary; Lawrence W. Bass, vice-president in charge of research and development; and Harry A. Sandstedt, treasurer.

UNITED STATES POTASH COMPANY emerged from a "wild cat" oil well drilling venture of two men in July 1925, in southeastern New Mexico, about 22 miles from the old cow-town of Carlsbad on the Pecos River. This exploration was for Snowden & McSweeney Co., independent oil producers, on public land selected by V. H. McNutt, consulting geologist of Tulsa, and supervisor of the project. At about 700 ft. a salt formation was encountered, which proved to be about 1,200 ft. thick, samples of which were pink-colored with dark red streaks running through them. Harry F. Schoonover, production superintendent, took these samples to the field office of Snowden & McSweeney at Fort Worth, Tex., to show John P. Shannon, vice-president in charge of field operations. Shannon was advised by his geologist, Louis H. Freedman, that the pink salt was potash and valuable if water-soluble. Stilwell & Gladding in New York confirmed the analysis, identifying samples of the material as water-soluble potash. Meanwhile McNutt was ordered to acquire prospecting rights on the "wild cat" site and adjacent lands, and succeeded in obtaining the right to search an area of 2,560 acres.

This was a highly expensive gamble, but Snowden & McSweeney determined that, in view of the great need for a domestic source of potash, the possibility of the discovery of important deposits warranted the advance of funds for exploration. Inasmuch as Snowden & McSweeney Co. was an oil company, the interested parties made the necessary advances from their personal funds. A core test drilled in Apr. 1926, gave further evidence of a bed of potash comparable to or superior in quality and availability to the better types of German and Alsatian ores. By July 10, 1926, expenditures totaled approximately $47,000, nevertheless the group decided to continue exploration. On Dec. 15, 1926, the American Potash Co., whose name was changed to United States Potash Co. in 1929, was incorporated in New Mexico, with a capitalization of 5,000 shares. It acquired by assignment the original potash-prospecting permit and two potash leases subsequently issued by New Mexico in neighboring areas.

Further core tests were drilled in 1927 and late in the year Snowden & McSweeney stockholders advanced additional funds against promissory notes of the potash company. In 1928 V. H. McNutt inspected potash mines in Germany, France, and Poland to help evaluate the discoveries in New Mexico.

An effort in 1929 to get financial assistance from J. P. Morgan & Co. failed, due to an adverse opinion on the project made by the Guggenheim Bros., Jan. 1928. However, Snowden & McSweeney and associates continued to finance the project from their own capital. By the summer of 1930, 23 core tests had been sunk and a shaft to cost over $700,000 commenced. All the money came from three individuals and one trust estate. By this time, however, some of the backers felt the economic depression. Additional capital was essential if the project was not to be abandoned and all of the money already expended completely lost. Moreover, a need was felt for the collaboration of persons or organizations with experience in mining and chemical processing. But search failed to locate any American

capital willing to take the necessary risk, despite the relatively advanced stage of the undertaking. Then James H. Snowden was approached by representatives of the Pacific Coast Borax Co., who indicated an interest in joining. During and after World War I, this company, producers of the famous 20 Mule Team brand of borax, had spent large sums in exploration for potash without success. After inspecting the Carlsbad core, Clarence M. Rasor, the field engineer, became highly enthusiastic about the possibility of a large-scale potash enterprise. As a result of negotiations in Sept. 1930 between Christian B. Zabriskie, vice-president of the borax company, and Snowden and McNutt, each stockholder of the potash company sold to the borax company one-half of his common stock, the total amounting to $2,000,000. The authorized common stock of the company was increased from 5,000 to 7,500 shares, the additional 2,500 being purchased at $100 per share, one half by the original prospecting group and one half by the Pacific Coast Borax Co.

Subsequent financing was marked by many difficulties, complicated by the depression. To repay the borax company for advances and to provide additional working capital, the Company issued 10% gold notes which were later converted into 10% preferred stock. By 1937 this was replaced with an issue of 6% preferred stock. In 1944, by an issue of 4% preferred stock which was sold to private investors, the Company was able to retire its outstanding 6% preferred stock and obtain funds needed for further plant expansion and improvements. All of the outstanding preferred stock was redeemed in Aug. 1946.

In 1931 holders of common stock were issued 14 shares in place of each share then held, increasing the common stock to 105,000 shares, and in 1933 a stock dividend of four shares for one was paid to holders of common stock. No further changes in common stock were made until 1946, when a stock dividend of one additional share for each share held was authorized, bringing the total to 1,050,000 shares. As of the end of 1946, the Company had no funded debt, no preferred stock, and no bank indebtedness. During 1944-45, the Pacific Coast Borax Co. successively reduced its holdings until at the end of 1946 it held 30.8% of the outstanding common shares.

Under the Potash Leasing Act of 1927 and Department of the Interior regulations, the U. S. Potash Co. assembled prospecting permits aggregrating about 7,500 acres of federal public domain, including the lands on which it had been prospecting. It obtained titles to three 20-year leases, on Nov. 21, 1929, from the Secretary of the Interior. Three additional leases were granted by the Department of the Interior in 1932, bringing the total holdings to 15,360 acres. New Mexico also granted several leases, which after several years' prospecting were consolidated into one covering approximately 31,672 acres. The Company also acquired fee ownership of mineral rights in land bearing potash in the midst of its leased acreage. Rights of way over private and public land were also secured for power and telephone lines and a narrow-gauge tramroad between the mine and refinery.

Work on the shaft at the mine site, commenced late in 1929 midway between two potentially commercial core tests, was completed on Jan. 9, 1931. Exploratory operations revealed ore of high potash (K_2O) content which made it marketable as manure salts. Fertilizer manufacturers, wishing to see an American industry succeed and further induced by favorable terms, encouraged immediate shipment of this run-of-mine ore, which totaled 41,419 tons or 10,738 tons of K_2O by the end of 1931. During 1932 further exploration definitely established an ore body of exceptional grade and substantial tonnage, and on June 1, 1932, the Company officially entered the production stage, constructing a refinery with a daily capacity of 120 tons of high-grade muriate of potash.

That year the Pacific Coast Borax Co. sold to the Company a narrow-gauge

railroad and advanced sufficient funds for its construction as a connecting link between the mine and the refinery located near the Pecos River about 17 miles south of the mine. The refining process depended upon selective leaching of the ore to dissolve out the potassium chloride, leaving the waste salt undissolved, and subsequently recrystalizing from the solution the chloride averaging 62½% K_2O. Production in 1932 amounted to 97,000 tons of crude ore and 10,762 tons of high-grade muriate of potash. Practically all the potash was sold to fertilizer manufacturers. Despite the high freight rates from Carlsbad to the Southeast where much of the fertilizer is manufactured, the Company was able to compete favorably with foreign importers of potash.

The period of 1933-39 was one of constant improvement in mining and refining processes, of increased production, and successful competition for a share of the American market. At the outbreak of World War II, in anticipation of an enormous shortage of potash in the United States, Canada, and Cuba, the U. S. Potash Co. canceled its export contracts with a Japanese firm and prepared to meet increased requirements of the domestic market. By early 1940 it had greatly enlarged its refinery and power plant. In 1941 the Company broke all previous records by producing 246,242 tons of high-grade, and 15,013 tons of 50% granular muriate of potash. The granular product was first marketed in quantity in 1939.

With our entry into the Second World War, plans were immediately made once again to expand refinery capacity. The success of the undertaking, despite the difficulties encountered, is illustrated by the large increases in output for each war year, with the peak in 1946—an increase of 150% over 1939 production of refined potash. Much of the production which had formerly gone to fertilizer manufacturers was diverted to the chemical industry, while the potash remaining for fertilizer use played a vital role in the record-breaking production of American foodstuffs. The plant remained in operation 24 hours a day throughout the entire war.

The Company's earlier research activities were carried on at Carlsbad, at the Missouri School of Mines at Rollo, Mo., and at the laboratories of the Pacific Coast Borax Co. in California. The borax company chemists, headed by Thomas M. Cramer, George A. Connell, and Frederick Biek, designed the potash refinery and all its accessory works, aided by engineers of C. C. Moore & Co. of San Francisco, which was to be the contractor on all subsequent refinery construction and expansion, including the huge new plant development in 1944-45. In the mining branch of the Company's activities, Clarence M. Rasor of Pacific Coast Borax Co. directed research and planning, ably assisted by Colwell A. Pierce, the experienced engineer brought into the Carlsbad explorations by V. H. McNutt in 1929. Geologists Joseph P. Smith and Paul Kern engaged in scientific studies, correlation of core tests, and mine and refinery research problems. Smith is now chief geologist of the Company, and recently a member of a Department of Commerce team organized to study potash production techniques in Europe. At Carlsbad, research is carried on in a special laboratory at the refinery, while at the mine, studies are always in progress to perfect milling and concentration processes. Laboratory work resulting in a process for making potassium sulfate was carried on in California, but production of this compound has not been undertaken.

As exploration, discovery, and development of this potash property continued, the Company had the advantages of the interest, enthusiasm, and active cooperation of the U. S. Geological Survey, whose Conservation Bureau was charged with the supervision of core drilling and mining operations on the public domain. Director Walter C. Mendenhall of the Survey, Herman Stabler, for eight years chief of the Conservation Bureau, and especially Howard I. Smith, chief of the Mining

Division and best-informed man on potash in the Department, were the important men involved. Smith is still (1947) the active head of all mineral leasing operations on the public domain, including potash mining in New Mexico.

In 1935 U. S. Potash Co. joined with the American Potash & Chemical Corp. of Trona, Calif., the Potash Co. of America at Carlsbad, and the European importing company, N.V. Potash Export My., representing German, French, and other selling agencies, in forming the American Potash Institute. This Institute, which has headquarters in Washington, D. C., and branches in Canada, Atlanta, Georgia, Lafayette, Indiana, and San Jose, Calif., is solely an agricultural research agency and has nothing to do with the commercial distribution of potash. It is headed by Dr. John W. Turrentine, foremost authority in the United States on potash as a plant food and formerly head of the Fert'lizer Division of the Agriculture Department. Soon after World War II broke out, N.V. Potash Export My., withdrew from the Institute whose activities continued under the sponsorship of the three large American producers of potash.

The first shipments of run-of-mine ore which began in 1931 were sold directly to certain large fertilizer manufacturers and indirectly to small mixers through Ashcraft-Wilkinson Co., fertilizer brokers. Direct sales were handled by Frank M. Jenifer and Walter F. Dingley, of the Pacific Coast Borax Co. Selling was on the basis of a price c.i.f. Atlantic ports, in order to compete with importers. In 1940 a substantially lower price f.o.b. Carlsbad was introduced. In May 1931 the Company established its own Sales Department, consisting of a vice-president in charge of sales, a sales manager, and two salesmen. A branch office was established at Atlanta, Ga., followed by others at Richmond, Va., Meridian, Miss., and Columbus, O. Executive offices are located in N. Y. City.

Since 1941, except for two months in 1946, potash has been under government control as to its distribution. In 1941 U. S. Potash was directed by the Office of Production Management to make its high-grade muriate of potash available to chemical manufacturers before disposal for fertilizer mixture. In 1942 potash was placed under allocation by the War Production Board. The Company has been a member of the Potash Export Association, organized in 1938, and has exported its share of potash, including small quantities going to Japan prior to 1939.

Organizers of the Company in 1926 were Henry McSweeney and James H. Snowden, heads of Snowden & McSweeney Co. The legal structure of the Company was erected by Paul Speer, their counsel. When the Pacific Coast Borax Co. acquired a substantial interest in the Company, its president, Richard C. Baker of London, exerted a strong influence in developing the new enterprise. The Englishman and his associates in the borax business advanced funds when American investment houses were unwilling to risk support without control of a considerable portion of the common stock. The vice-presidents and general managers of the Pacific Coast Borax Co., Christian B. Zabriskie, 1929-32, and thereafter Frank M. Jenifer, now president of that company, contributed greatly toward making the potash company a healthy, growing concern in a highly competitive industrial field. Snowden died in 1930, Zabriskie in 1936, Baker in 1937, and McSweeney n 1946.

In 1931 Walter F. Dingley, formerly assistant to Baker and Zabriskie, was elected secretary and treasurer of the U. S. Potash Co. and set up an independent office for the Company in the Canadian Pacific Bldg. at 342 Madison Ave., N. Y. City. Mrs. Gertrude B. Stiehler, associated with Snowden & McSweeney Co. since 1925, was also transferred to this office. Production at Carlsbad was under the management of Clarence M. Rasor, then of Thomas M. Cramer, with Colwell A. Pierce as general superintendent in charge of mining operations. In 1933 Horace

M. Albright, a member of a pioneer mining family of California and Nevada, became vice-president and general manager. He had 20 years' experience as a lawyer and administrator in the Department of the Interior and over four years as director of the National Park Service.

In 1932 Jesse C. Devilbiss, for many years district manager of the Virginia-Carolina Chemical Co., was appointed sales manager of the Company, and next year Andrew A. Holmes, sales manager of the American Potash & Chemical Corp. in the 1920's, was made vice-president in charge of sales. He died in 1939 and was succeeded by Devilbiss, who died suddenly in Nov. 1946. These two vice-presidents were largely responsible for the Company's sound and effective sales policy.

Most of the present officers of the Company and management personnel have been with the organization since its early days (date in parentheses). The New York staff includes: Horace M. Albright, president since 1946 (1933); Frank M. Jenifer, vice-president (1937); Paul Speer, vice-president and general counsel (1926); Walter F. Dingley, secretary and treasurer (1931); Albert W. Davis, controller and assistant treasurer (1932); Gertrude B. Stiehler, assistant secretary (1925); James E. Barnes, vice-president, sales (1940); Philip Janicola, traffic manager (1932). At Carlsbad, management is under: Thomas M. Cramer, vice-president and resident manager (1930); Colwell A. Pierce, general superintendent (1929); Henry H. Bruhn, refinery superintendent (1932); L. Hollister Jones, industrial relations director (1942); Joseph P. Smith, chief geologist (1929); Dr. Karl Jacobi, chief chemist (1930); Thomas McGivney, chief engineer (1932).

UNITED STATES RUBBER COMPANY is in the main a producer of rubber and a fabricator of rubber products, but it is also a chemical company. Its products include such seemingly diverse lines as insecticides, aromatics, plastics, and textiles. Nevertheless, these products evolved logically from chemical research and development, which started half a century ago when the Company founders foresaw that in chemistry lay the secret of making rubber a more serviceable material. The Company was organized in 1892, when a group of Eastern rubber footwear manufacturers united for more economical operation. Some of the joining companies date back virtually to the discovery of the vulcanization of rubber. Two were original licensees under the Goodyear patent in 1843. One, Goodyear's Metallic Rubber Shoe Co. at Naugatuck, Conn., is still in operation, making it the oldest rubber-manufacturing unit in the country.

The chemical activities of U. S. Rubber Co. stemmed from the chemical nature of rubber manufacturing. Trained chemists were hired early in its history. The actual production of chemicals by the Company started in 1904 with the formation of a subsidiary, the Naugatuck Chemical Co., to manufacture the sulfuric acid involved in reclaiming rubber. The original board of directors of the new company included Commodore Elias P. Benedict, president; James B. Ford, vice-president; and Charles E. Sholes, secretary and manager; with Matthew Adgate, veteran acid manufacturer, as plant superintendent. There was a ready market for the surplus acid produced among the brass companies in the neighborhood, if other acids could also be supplied. Naugatuck Chemical found it had the technical background for manufacturing nitric, acetic, and muriatic acids and proceeded to install additional facilities for their production. During the few years preceding World War I, the Company consolidated its chemical production facilities and withheld for a time any further expansions. Its margin of profit was not great because of a current acid price war.

In 1913 the reclaimed-rubber facilities of the U. S. Rubber Co. were partly

converted to the caustic soda process with the purchase of the Rubber Regenerating Co., where Raymond B. Price had perfected and applied this process. Price became vice-president and undertook to place the Company's chemical development on a firm scientific basis. He brought together a group of graduate chemists and physicists and organized the Company's General Laboratories.

When World War I broke out, U. S. Rubber was cut off from its German supply of aniline oil, then the chief rubber accelerator and softener. By Jan. 1915, its tire plants had only four months' stock. The Company quickly installed equipment and acquired technical personnel to produce aniline oil. The first batch was placed in drums while still hot and shipped to the tire plants in time to prevent a shutdown. Thus was started one of the first aniline plants in the country. Meanwhile, the Company had been conducting research on various organic compounds to find improved vulcanizers. One of these, thiocarbanilide, was particularly promising and a factory process was devised for its production.

During the early twenties a greatly enlarged program of organic research was begun and technically trained men were added to the staff. This new emphasis was the start of the Company's great growth in the production of tailor-made chemicals. It produced a new idea in rubber technology. During the course of examining many different compounds as possible accelerators of cure, a storehouse of rubber samples containing these compounds had been accumulated and a careful record of their characteristics had been kept. When the laboratory undertook to find a chemical that would make rubber resist "old age," the first step was to reexamine these samples. With the aid of the records of how the samples were originally prepared, it was possible to select the chemical which was the greatest age-resistor. But the material was not the best of accelerators, so further research was conducted on this chemical alone until a closely allied compound was found which maintained the age-resisting qualities of the original but did not affect the rate of cure. This was the first successful rubber antioxidant. Marketed as VGB in 1924, this material rapidly expanded to a peak of several million pounds per year. Eventually, however, VGB had to bow to its superior, the secondary amines. U. S. Rubber's contribution to the amine-type of product was BLE, which grew in favor until one-third to one-half of all tires produced in this country were protected with it.

Backed by its chemical research, the Company prospered in the manufacture of rubber chemicals, its sales more than tripling during the twenties. From the start, it followed the policy of making its chemicals available to all rubber-goods manufacturers and of freely licensing others to manufacture under its patents. U. S. Rubber is the only large rubber company that has sold its rubber chemicals directly to its competitors.

Also in the twenties, the Company intensively studied liquid rubber latex itself and succeeded in using it directly as a raw material. This pioneering achievement was accomplished only after techniques were devised to protect latex against putrefaction during shipment and storage. This involved studies of latex particle size, particle charge, and other colloidal properties; and of the best methods of adding curing agents, antioxidants, and accelerators to make the latex vulcanize. U. S. Rubber was the first to bring commercial quantities of latex to the United States. Creaming and centrifuging methods doubling the solids content greatly reduced shipping costs.

The first commercial use of latex was in speeding tenfold the manufacture of pile carpeting and similar fabrics. As the demand for latex compounds increased, the Company made available to other manufacturers a line of products called Lotols in which latex was especially compounded for special applications. The

Lotols led to the discovery of other forms of "liquid rubber." U. S. Rubber purchased the patents on crude rubber dispersions which are similar to rubber in its latex form and which can be compounded like latex.

Meanwhile work was continuing on new rubber chemicals. One of the more prominent was Hepteen, an accelerator made from heptaldehyde and aniline. Naugatuck had been producing aniline for years. But heptadehyde was still a laboratory curiosity. The Company perfected a continuous thermal-cracking procedure for making this chemical from castor oil and became probably the largest heptaldehyde manufacturer in the world.

The first punch of the depression was blocked by consolidating the chemical and reclaim activities in Naugatuck Chemical Co. During this decade all divisions of the Company were aided by previous and current mastery of rubber technology. With a background of latex chemistry, the laboratories devised a technique of producing a continuous, round rubber thread to replace the coarse, square-cut threads previously used in elastic fabrics. Latex chemistry also provided an insulating wire covering of uniform thickness, called Laytex, and made possible latex foam, called Koylon, which provided a highly desirable self-ventilating cushioning material.

During the depression the Company continued to expand in rubber chemicals and also branched into two allied activities, aromatics and agricultural chemicals. Having become a large-scale producer of heptadehyde, it sought to find other uses for this basic chemical. A process was worked out to produce the jasmine odor base, amyl cinnamic aldehyde. Here was the start of the Aromatics Division, which produced pleasant scents for soaps, cosmetics, and other products. Other early synthetic aromatics were the violet-scented ionones from lemon grass oil. To gain previous experience in this complicated field, the Company arranged for scientific collaboration with the Louis Bornand Laboratories of Paris, and Bruno Court of Grasse, France, an essential oil and perfume business for over 100 years.

Realizing that such diversification of products was advantageous during the depression, the Company decided to examine the thousands of organic compounds it had developed as possible rubber chemicals, for insecticidal and fungicidal action. Extensive trials in greenhouses and in the field pointed to one promising compound, which led to the development of Spergon and Phygon, two fungicides which greatly improved seed germination and crop yields. An insect killer called Syntone was also developed. This research in agricultural chemicals has grown until today the Company operates a special laboratory for development of improved pest poisons.

Research on textiles resulted in a chemical treatment that worked on the natural waxes of cotton fibers to reduce their slippage over each other. The development made possible a cotton cord, called Ustex, with greater tensile strength, providing an improved material for tire fabrics. A stretching operation further increased the cotton strength as much as 70%, making this improved Ustex ideal for use in high-pressure steam hose and heavy industrial belts. During the recent war, Ustex proved to be stronger than linen when substituted in parachute harness webbing.

When the Japanese closed the door to the Far Eastern rubber plantations, U. S. Rubber was prepared to help establish a rubber industry to replace the output of a billion rubber trees. Starting in 1925, a small synthetic rubber pilot plant was operated by the Company for several years. Here the process for making butadiene from alcohol was investigated. Other pilot plants were operating on the manufacture of styrene. In 1940 the pilot-plant work was resumed on syntheic rubber formulations. Particular attention was given to dodecylmercaptan which gave a synthetic rubber of any desired viscosity, from a soupy mush to a hard bark-like material. A process was worked out to make this chemical, coded OEI, which

was later appropriately nicknamed the "One Essential Ingredient." By the time the United States entered the war, U. S. Rubber was producing OEI and was familiar with its use in making synthetic rubber. It operated a government plant which supplied the major portion of this synthetic rubber modifier used during the war.

U. S. Rubber also pioneered in synthetic rubber production, designing and building one of the first three plants. Later many of the process and plant design features were adopted in establishing the Government's standard plant synthetic rubber program. The Company laboratories succeeded in developing more new varieties of synthetic rubber than all other laboratories in the industry combined. An improved BLE, the standard rubber antioxidant, was made; also, two non-staining antioxidants, EFED and IBUL, were discovered to permit production of white and colored synthetic rubber products. During the war U. S. Rubber also operated TNT plants for the Government.

The fundamental research with synthetic rubber was found applicable in solving war problems in the plastics field and established the Company in a new line of postwar products. To supply the Navy with fireproof upholstery fabrics, U. S. Rubber chemists sought to improve Naugahyde, a woven fabric coated with a rubber compound. They found that a plastic could be substituted for the rubber, making Naugahyde not only fireproof but also superior in other respects. Today it is in demand for theater and restaurant upholstery. U. S. Rubber Vibrin sheeting material, reinforced by imbedded glass cloth, proved itself as the outer casing for the rubber self-sealing fuel cells on planes. Vibrin resins treated with a chemical known as a promoter were ideal for deactivating unexploded enemy bombs. Among the peacetime uses for the Vibrins are many molded articles from clock cases to lightweight boats. Another plastic which formed the radar domes of B-20 bombers will be fabricated now into lighter, tougher traveling bags. A superior baking enamel called PQL promises chip-proof, nonyellowing finishes for steel kitchen and commercial appliances and designs on glass and ceramic products. Two postwar resins, Koloc and Kandar, are now ready for textile finishing. The former is an improved shrink-preventive for woolens; the latter is called a "permanent starch" since it stays in the cloth through repeated launderings to give cottons and rayons a lasting crispness and body.

These are the activities that have grown out of U. S. Rubber Co.'s chemistry. Rubber has been made a more serviceable material through the conquest of its liquid forms and the development and perfection of new and better rubber chemicals. Application of these fundamental developments in other fields has evolved into such lines as pest poisons and aromatics. Finally, intensified organic research has opened a storehouse of synthetics, starting with synthetic rubber and today pushing out into the high polymers. U. S. Rubber plastics and resins are but the first fruit of this research. Meanwhile, rubber itself, is being improved.

The Company's sales of chemicals have steadily grown through war and depression. At present its dollar volume of chemical business is double that just prior to the last war.

UPJOHN COMPANY was founded by Dr. William E. Upjohn, a young physician of Hastings, Mich., who moved to Kalamazoo in 1885 to form a partnership with his three brothers for the manufacture of pills by a new process which he had patented. Following the death of one of the brothers, a corporation was formed in 1887 with capital stock of $60,000, of which $27,000 was paid in cash. The stockholders were mainly citizens of Kalamazoo, one of whom was

John Gilmore, merchant. The first president was Dr. Upjohn, who retained the office until 1930, two years before his death.

The corporate title was the Upjohn Pill & Granule Co. until 1902, by which time the original "pill factory" had become a general pharmaceutical house. The name was then changed to the Upjohn Co. Until then and for some time afterward, the work of the chemical laboratories required little more than assay and simple pharmaceutical chemistry. In 1913 Dr. Frederick W. Heyl, then professor of chemistry at the University of Wyoming, became chief chemist. His interest in chemical research initiated the gradual development of the research laboratories. Research problems arose from analytical control, whence the firm became deeply interested in the preparation and distribution of digitalis products. This led to investigations of other cardiac drugs, such as strophanthus and *Adonis vernalis*, but digitalis retained the prime interest. The research laboratory devoted to phytochemical research, under Drs. Heyl and M. C. Hart, operated continuously in investigating drugs from plant sources, particularly the chemical components of ragweed pollen.

With the prodigious advance in biochemistry, which led to the understanding of fat-soluble and water-soluble vitamins, the laboratory undertook the physical, chemical, and biological study of vitamins A and D and at an early date marketed standardized vitamin preparations. The first to become well known was Super D Cod Liver Oil. Extensive data were accumulated which had bearing on the seasonal and geographical selection of vitamin-bearing oils and surveys were extended to other varieties of liver oils. Familiarity with the chemistry of lipoids led to the study of vitamin concentrates. Super D Cod Liver Oil and Super A Concentrate were marketed under a license from the International Vitamin Corp. (Marcus, U. S. Patent 1,690,091). Improvements by Edwin C. Wise, Clyde Caldwell, and associates have greatly lowered the original cost of these pharmaceuticals. About the maximum in extraction and concentration of natural water-soluble vitamins was reached in 1937 when Wise, Dr. Heyl, and R. A. Delor developed a practical product which was marketed under the trade name, Cerelexin Tablets. This was superseded shortly by a variety of more potent, synthetic vitamin preparations.

In the laboratories of pharmacology and endocrinology, under Drs. George F. Cartland and Marvin H. Kuizenga, attention was directed in the 1930's to the isolation of economic preparations of estrogenic hormones from urine and gonadotropic hormones from serum of pregnant mares. The one from serum was marketed as Gonadogen, after agreement with Professors Cole and Hart at the University of California (U. S. Patent 1,994,853). Investigation of the chemical structure of this hormone was halted when it became necessary for Dr. John Evans to turn his attention to the penicillin problem. U. S. Patent 2,053,549 covers an Upjohn process for producing an active and stable extract containing adrenal cortex hormones. This product is marketed in cooperation with Dr. J. M. Rogoff under the Rogoff and Stewart basic U. S. Patent 2,096,342. Research work in the adrenal cortex field has been expanded to include fractionation studies of the hormones in the glands of sheep and cattle. This and the preceding developments have led to an elaborate extension of the technical and scientific staff in recent years. Cooperative research with academic and medical authorities has been concurrently developed and a wide variety of publications on pharmaceutical and medical subjects has resulted.

A group of organic chemists headed by Dr. M. C. Hart and the bacteriological laboratory have made long studies on antisepsis and germicides, resulting in the production of two powerful germicides, amyl cresol and *o*-hydroxyphenylmercuric

chloride. This work led to the marketing of Mercresin. Dr. Eugene H. Woodruff of this group developed an economic method for diethylstilbestrol manufacture.

Dr. John Norton cooperated closely with Dr. Pearl Kenyon at the Michigan State Department of Health in the study of a modified pertussis vaccine, a product which was marketed in 1936. Dr. John T. Correll and his staff, who have studied blood clotting and anticoagulants, have recently perfected an absorbable surgical sponge, which has been marketed under the name Gelfoam. With the advent of sulfa drugs, a large number of new substances of this class were prepared and studied. Likewise a continuous interest in both antispasmodics and hypnotics has been maintained. All these are developments prior to World War II.

An early milestone in drug distribution, which considerably advanced the status of the Company, was the marketing of Phenolax Wafers in 1908, the first of the phenolphthalein confections to become popular. Another was the introduction of a palatable effervescent preparation of mixed alkalies, called Citrocarbonate. The consequent increase in the number of retail distributors for the Company's products encouraged the establishment of branch offices, which at this time (1948), number 14, in Boston, New York, Atlanta, Memphis, Cleveland, Chicago, Dallas, Kansas City, Minneapolis, San Francisco, Los Angeles, Portland, Kalamazoo, and Toronto. Orthodox methods of pharmaceutical distribution have been followed, mainly through salesmen and "detailers," with some pharmaceutical or scientific background and training.

Upjohn products embrace a general line of the usual competitive pharmaceutical preparations as well as numerous special, trade-marked products. These include vitamins, endocrine products, chemotherapeutic agents, germicides and antibiotics, and cardiac drugs; also digestants, antacids, cough sirups, laxatives, effervescent salts, liver products, and liver and iron preparations. Distribution is through four channels: wholesale druggists, retail druggists, hospitals, and dispensing physicians.

The original "pill factory" on E. Lovell St. in Kalamazoo, a small four-story building, was augmented by the addition of a new building about every five years, until in 1948 the Company occupied 42 buildings aggregating an area of 987,000 sq. ft. This includes modern buildings dating from 1934, among which are a large factory building, a concentrate plant for making cod liver oil, and a new office building at the site downtown, and a large warehouse two miles north of the city covering 200,000 sq. ft. with railroad sidings. In 1943 a soft capsule plant was built, and in 1944 a factory building was purchased and re-equipped for the manufacture of penicillin. Subsequently the Company acquired some 1,500 acres of land six miles south of Kalamazoo where an antibiotic plant has been erected and where a large-scale building program is in process.

The present officers and directors are: Dr. L. N. Upjohn, chairman of the board; D. S. Gilmore, president and general manager; Dr. M. C. Hart, vice-president and director of research; Dr. E. G. Upjohn, vice-president and medical director; C. V. Patterson, vice-president, production; Wm. F. Allen, vice-president, sales; L. M. Crockett, vice-president, engineering; J. B. Vanderberg, secretary; D. G. Knapp, treasurer; and W. F. Little, superintendent, production. Other directors are Mrs. Grace B. Upjohn, Mrs. Dorothy U. DeLano, Mrs. Genevieve U. Gilmore, Dr. Richard U. Light, and Dr. S. R. Light, formerly vice-president of the Company.

VAN AMERINGEN-HAEBLER, INC., grew in 1929 out of the joining of two firms, van Ameringen, Inc., and Morana, Inc., which were already well established in the aromatics, essential oil, and flavor business. As a branch of Compagnie Morana, an old Swiss aromatics house, Morana, Inc., had been established in 1909 to manufacture aromatic chemicals and import perfumery materials, also acting as agents for Haarmann & Reimer, foremost European producers of aromatic chemicals, and Bruno Court of Grasse, France, producers of essential oils and natural flower oils.

A. L. van Ameringen, today president of van Ameringen-Haebler, Inc., was born and educated in Holland, where he became active in the essential oil and perfume business. Coming to the United States in 1917, he established himself as an importer of perfume materials, and in 1925 broadened his activities by establishing a laboratory in Orange, N. J. The first α-amyl cinnamic aldehyde made in the United States was produced there. Dr. William T. Haebler, treasurer of the Company, graduated from the Massachusetts Institute of Technology and later received his Ph.D. at the University of Zurich. Upon his return from Switzerland he became affiliated with Morana in 1925.

The new company with its headquarters and sales offices at 315 Fourth Ave., N. Y. City, enlarged and re-equipped the Elizabeth aromatic chemicals and flavors plant formerly operated by Morana. Emphasis on research resulted in many new chemical products, added to the old line of geraniol, rhodinol, ionones, benzaldehyde, citral, citronellol, etc. Special attention was paid to assisting the American perfume and cosmetic industry to become independent of European suppliers, on whom in 1929 it still was largely dependent. The research laboratory also developed many new chemical compounds which were used by the staff of master perfumers to create many new specialties. This activity has become of major importance and the Company's perfume specialties are used all over the world.

The research section of the Flavor Department through microchemistry investigates the constituents of natural flavors, a study that has resulted in the production of greatly improved synthetic fruit flavors. During the war, van Ameringen-Haebler, at the request of the Army and Navy, spent considerable time developing concentrated flavoring agents in tablet form, and three lines of production machinery were installed in the Elizabeth plant to produce these tablets.

VAN CLEEF BROS., INC., began as a partnership in Jan. 1910, when Maxime and earlier Noah Van Cleef, joined the young chemist-brother Paul Van Cleef (M.S., University of Chicago), who had established a small, promising rubber-cement manufacturing plant in Chicago in May 1909. In July 1912, another brother, Felix, came into the business. The work of these four brothers was divided, Paul supervising manufacturing processes, Noah in charge of administration, and Maxime and Felix sent out as salesmen.

In the beginning a department devoted to the wholesaling of bicycle accessories was maintained, but as the business progressed, this was discontinued and the firm became a purely manufacturing enterprise. Despite the hardships brought about by World War I and the depressions of 1921, 1929-32, the Van Cleefs prospered. Buildings were remodeled, additional property acquired on Woodlawn Ave., more machinery added, and more men sent on the road. The plant now consists of three units known as Plant 1, Plant 2, and Plant 3.

At present the Company numbers among its accounts some of the largest and most important firms throughout the country, including electrical, automotive, hardware, notions, drug, groceries, and numerous industrial fields. Distribution

of its products is world-wide and the trade-mark, Dutch Brand, is known everywhere. These products consist mainly of those involving the use of crude and synthetic rubber, going from liquid cements to molded parts and coated materials, and including a large variety of industrial tapes. Other products are intended for the maintenance and repair of automobiles, including rubber cements, gasket shellac compounds, hydraulic brake fluid, tire repair materials, etc. All products bear the Dutch Brand trade-mark.

When the latest addition to the plant was completed in Sept. 1944, it included a very fine modern laboratory staffed by expert chemists. At present approximately 300 people are employed in the plant. Labor-management relations have always been of the finest. Group life insurance and a group hospitalization plan are provided for all employees, 31 of whom h ve been with the Company for over 25 years.

In June 1946 the partnership was converted to a corporation, Van Cleef Bros., Inc., with Noah Van Cleef, president and treasurer; Felix Van Cleef, vice-president; Paul Van Cleef, vice-president and secretary. Maxime Van Cleef retired from the partnership in 1937.

Several members of the firm have been very active in civic work: Noah Van Cleef in the Chicago Heart and Illinois Manufacturers' Associations; Paul Van Cleef being president of the Greater Chicago Safety Council and prominent in the University of Chicago's cultural work; Felix Van Cleef a tive in the Community Fund and Red Cross.

VAN DYK & COMPANY, INC., which has been described as "one of the incubators in which the premature infant coal-tar aromatics industry was nurtured," was one of the first American manufacturers of synthetic aromatic perfumery chemicals and other perfumery raw material, and continues to rank among the leaders in this industry. It also manufactures flavoring materials, as well as a wide and diversified line of cosmetic raw materials, such as absorption bases, emulsifiers, fatty acid esters, emulsion stabilizers, bromacid solvents, preservatives, antioxidants, antiseptics, sunscreens, wetting agents, etc. The Company was organized in 1902 by Dr. Samuel Isermann and the late L. A. Van Dyk, and incorporated in 1904. Van Dyk severed his connection with the Company about 1910 and it has since been under the management of Dr. Isermann. His brother, Max Isermann, who died in 1947, was actively associated in the management for a number of years.

The Company began to manufacture synthetic aromatic perfumery chemicals on a laboratory scale in 1903, on Cedar St., N. Y. City, in modest quarters consisting of an office and laboratory. As operations expanded, it moved to larger quarters at 131 Maiden Lane, and eventually to 4-6 Platt St., where it was located for several years. In 1914, at the beginning of the First World War, the Company established a factory in Jersey City, N. J., to which its offices were eventually moved. In 1943 a larger factory was acquired in Belleville, N. J., where the Company is now located.

At the outset there was practically no market for synthetic aromatic perfumery chemicals in this country, although they were being extensively used and manufactured in Europe. Nor were there, generally speaking, any raw materials, either coal tar or non-coal tar, for these products in this country. Both raw materials as well as finished products were imported from Switzerland, Holland, and France, but mainly from Germany. Even the necessary glassware was imported. The finished products were sold at prices which made their use practically prohibitive, and were marketed largely under fanciful, nondescriptive names. So in addition to

the raw materials problem, the Company faced the twofold problem of educating the perfumery industry in the advantages offered by the use of synthetic chemicals and of overcoming the then-existing prejudice against domestic organic chemicals generally.

A further obstacle was the prejudice among perfumers generally against using chemicals, particularly those of coal-tar origin. This prejudice existed despite the fact that a number of chemicals were already being used in perfumery, such as coumarin, ionone, vanillin, terpineol, heliotropin, and geraniol, although most perfumers were unaware that these products were chemicals, thanks to the uninforming labels under which they were sold. As a result the Company's initial progress was slow. Through sustained research work, a wide line of aromatic products, comparing favorably in quality with the foreign brands, was gradually developed and a market created through prolonged educational work. This work done by the Company among American perfumers is generally acknowledged to have been a dominant factor in establishing the broad market that exists in this country today for synthetic aromatic perfumery chemicals.

Characteristic of these results is the important position that the aliphatic aldehydes and alcohols occupy today among the raw materials used by the American perfumer. Originally these products were made only in Germany, Switzerland, and Holland; they were practically unknown in this country. About 1908 Van Dyk & Co. began to manufacture them on a laboratory scale. Today there is practically no fine perfume in which an aliphatic aldehyde or alcohol is not used, either to impart a distinctive, individual odor or to give a top note.

The introduction of the Company's products and those of other American manufacturers had an important influence in forcing reduction of the prices of European products sold here, thereby making the use of synthetic aromatic perfumery chemicals economically feasible. A typical example is the price history of ionone, one of the most important raw materials used in perfumery. When Van Dyk began the manufacture of ionone, the price of the European product in 100% strength was $1,000 per lb. The Company sold its ionone, of a quality equivalent to the imported product, for $75 per lb., which eventually became the price of the European product. Prices of other synthetic aromatic chemicals eventually followed a similar downward trend.

When World War I broke out, the Company, like practically all the American manufacturers of organic chemicals, was faced with the alternative of either manufacturing its own raw materials or going out of business. It thereupon began manufacturing raw materials for drugs, dyes, and organic chemicals for its own use, as well as for resale to other manufacturers. Upon United States' entry into the war, a new difficulty arose, due to the fact that some of these raw materials were also needed in the manufacture of war materials. The Company thereupon diverted a large part of its facilities to the manufacture of high boilers, plasticizers, and other products used in aircraft. A large number of intermediates used in perfumery, such as benzyl chloride and benzyl cyanide, of which the Company was for a short time the sole source of supply, were used in training soldiers for chemical warfare. A number of other products made by the Company were supplied to various governmental departments, especially for research and for aircraft production.

During the Second World War, the Company was a large producer of plasticizers and flash-retardants for smokeless powder and of insect-repellent material and sunscreens for the Army. It also developed a number of new emulsifiers for DDT, benzyl benzoate, and other insecticidal and insectifugal products used by the Army and Navy. These products are now being widely used for civilian purposes.

VERONA CHEMICAL COMPANY was incorporated in Jan. 1902, and about a year later manufactured its first product, saccharin, using imported *o*-toluenesulfonamide and potassium permanganate. The Company began research on other organic products, and the next chemical to be added was vanillin, when the chief chemist, Dr. Adolph Wack, discovered a process by which the yield ordinarily obtained at the time was considerably increased. The new process was patented here and in Europe, and was soon adopted by the largest European producer of vanillin.

The next project was the distillation of essential oils—clove, patchouli, sandalwood, nutmeg, and pimento berries—but this enterprise was given up a year or two later on account of sales difficulties. Undiscouraged, however, the Company branched into new fields and began making potash chrome alum and terpin hydrate (U.S.P. crystals and powder). Shortly after, manufacturing was expanded to include thymol crystals, made from ajowan seed grown in India. For a number of years the Company was the sole American producer of all these products.

In 1913 the Company entered into a contract which indirectly changed its entire policy. An arrangement was made with Dr. B. J. Flursheim of Fleet, England, for the sole American rights to tetranitroaniline. This product was taken over too late for a new and unknown military explosive to be introduced in this country; and all the Company efforts, even with the help of Dr. Flur heim, came to nothing. In making tetranitroaniline, it was first necessary, however, to make dinitrobenzene and *m*-nitroaniline, for both of which products Verona soon found there was an immense sale. The Company concentrated on them and gave up some of the old products altogether—terpin hydrate, thymol, and the essential oils. Vanillin and chrome alum, however, were retained. Early in 1916 the Company pioneered in the manufacture of sulfur black, the first American-made sulfur black sold to American dyers.

Since the vanillin required sulfanilic acid, no longer available from abroad, the Company took up its manufacture also; and this was only the starting point for a number of other coal-tar intermediates. The Company believes itself to be the first American manufacturer of a number of these: *o*-aminophenol, dinitrochlorobenzene, *m*-nitroaniline, *p*-chloro-*o*-nitroaniline, dichloroaniline, chloroanisidine, etc. Competition as to both price and quality had to be met, and in many cases entirely new syntheses had to be worked out for the Company to maintain its reputation for purity of product.

In 1938 the old management headed by Edwin Kuttroff sold out to new interests headed by Franklin H. Stafford. Under the old management emphasis had been on small production of difficult-to-make, high-grade, organic chemicals. The new management decided to retain the policy of making only the more difficult organics and to maintain the quality standards, but undertook to do these things while greatly expanding production. Under the old Company, hydroquinone, methyl-*p*-aminophenol sulfate, phenylethyl alcohol, and ionones were manufactured in very limited quantities; under the new, their production was modernized and the capacities increased. Since ionones and phenylethyl alcohol are largerly consumed by the soap trade and perfumers, it was decided to enter into the manufacture of aromatics. A research program was started and after several years new buildings were added to translate the results to full-scale plant production. A large number of aromatics such as special aldehydes, glycidates, and other specialties are now being manufactured.

The Company has a new well-equipped research laboratory, a staff of research chemists, and a production and engineering organization that can quickly and with

a minimum of red tape put new products into production. It guards its reputation for quality products and continues to expand along sound lines.

VICTOR CHEMICAL WORKS was born 50 years ago, under modest circumstances, and its growth so far has been closely identified with the personality of its present chairman, August Kochs. In 1897 Kochs, a young businessman with a background of chemistry, focused his attention on the manufacture of monocalcium phosphate. At that time he was associated with Peterson & Mansar, Chicago flour merchants. The firm was losing money on a manufacturing venture in Chicago Heights, Ill., where production of monocalcium phosphate for baking powder was being attempted with phosphate rock as a raw material, and Kochs was encouraged to determine whether or not the operation was worth saving.

Kochs found a small plant in rented quarters, which two men had started. The operators had no knowledge of chemistry and were blindly following inadequate instructions, spending $2,000 per month to produce material salable at only $1,200. In spite of the uneconomic nature of the operations, Kochs was intrigued with the possibility of obtaining a suitable product, and studied the literature available on phosphoric acid and phosphates, with a view of eliminating the immediate faults in the process and product. Shortly thereafter he assumed management of the plant and engaged a part-time chemist to work with him. Kochs spent his days making phosphates and his evenings trying to sell by letter. Within a year he developed a method of eliminating free acid from the monocalcium phosphate. This enabled the production of a pure, dry material, markedly superior to the former hygroscopic mass requiring the addition of starch or calcium sulfate.

About the time that prospects for the venture began to show promise, the owner of the building required the space for other purposes, and the youthful phosphate business was put out on the street. It was decided that the construction of a real chemical plant was warranted if sufficient capital was available. Local financing could not be found, so Kochs went East, where he demonstrated the quality of his product to Prof. C. F. Chandler at Columbia University. Impressed by Kochs and the demonstrations, Chandler recommended to William A. Read, the investment banker in New York, that capital be made available. As a result, Victor Chemical Works was incorporated in Illinois, Feb. 21, 1902, and in May ground was broken for a new plant at Chicago Heights.

Within a 20-acre tract several buildings were erected, including a power plant, office and laboratory, and elevator for storage of raw material. The layout was designed to manufacture "undiluted" monocalcium phosphate and pure phosphoric acid from bone. Walter B. Brown, now president, joined the Company as chief chemist in 1903, later becoming general superintendent. A graduate chemist of the University of Illinois, Brown had his sleeping quarters adjacent to the laboratory and a big watchdog for a companion. At that time the plant and laboratory employed about 25 men.

The next few years were spent in attempts to improve the purity of products, meet competition, and overcome sales resistance. From the beginning a definite program of research was an integral part of operations. During this period the Company had been following a celebrated case in England dealing with the hitherto unsuspected presence of arsenic in brewery products. As a result, Victor perfected a process eliminating the arsenic from food-grade phosphates. In 1907, to diversify manufacturing activities, the Company began the production of U.S.P. Epsom salt, using magnesite imported from Greece. Monocalcium phosphate remained the mainstay, however, and other phosphatic salts were added. In 1908 the Company made its first profit.

The business had grown and the supply of bone from the usual sources was becoming inadequate. To make a satisfactorily pure phosphoric acid from rock, however, presented serious problems; to eliminate iron, aluminum, and fluorine required first-class research not only in chemistry, but in chemical engineering and equipment design. Another undesirable impurity in the finished phosphate was lead, which was introduced from lead tanks and evaporators used in the processing. Metals resistant to corrosion were not then available and the use of stoneware and glass in a large operation was impractical. Means, therefore, had to be found for eliminating this impurity. A process was developed in Victor's research laboratory, which eliminated lead as the last step in the manufacture of the acid and thus lead-free phosphates became available.

The successful solution of these manufacturing problems resulted in the first major change in the Company's operations, and in 1912 a plant was built at Chicago Heights adopting the rock phosphate process, which was operated in conjunction with the original plant. Phosphate rock was used exclusively and the output of monocalcium phosphate, greatly superior to any previously manufactured, amounted to three times the former capacity. An ammonium phosphate department was later added, and the Company began marketing this chemical in 1915.

In Sept. 1915, Otto H. Raschke, now vice-president in charge of sales, joined Victor as sales manager and the following year William D. Webster, now vice-president of finance and comptroller, joined the Company.

When the shortage of sulfuric acid developed during World War I, Victor built a plant at Chicago Heights with a capacity of 20,000 tons per annum. Increased demands for Victor phosphates in 1918 resulted in the construction of a second sulfuric acid plant, bringing the total annual capacity to approximately 60,000 tons.

The pressure of wartime demands did not divert efforts from basic research, and in 1918-19 an experimental electric furnace was built at Chicago Heights, which produced good-quality phosphoric acid from phosphate rock, sand, and coke. Power consumption was high and costly in this pilot plant, and as at that time it became necessary to expand plant capacity, it was decided to build the new plant using the wet process. In 1919 a 40-acre tract was purchased at West Nashville, Tenn. Construction began in 1920, at a total cost of $1,106,000, and production of sulfuric and phosphoric acids and monocalcium phosphate was started Oct. 15. The process comprised decomposition of phosphate rock with sulfuric acid, with subsequent removal of calcium sulfate by means of Dorr equipment.

Prior to World War I, Victor had not made organic chemicals. In view of available coke, caustic soda, and sulfuric acid in the Chicago area, the Company was prevailed upon to build a plant in 1917 for the production of oxalic acid along the lines of the Goldschmidt process. Actual production began about the time of the Armistice, when imported oxalic acid was selling at 40¢ to over $1 per lb. Operations were complicated and expensive, and soon a flood of foreign imports endangered the business. The duty of 4¢ per lb. on oxalic acid was inadequate and manufacture would have been abandoned had not President Coolidge in Dec. 1924 proclaimed an increase in the tariff to 6¢ per lb., under the flexible tariff provisions of the Act of 1922. This, together with improvements in the process, saved the American oxalic industry.

Formic acid, like oxalic acid, is made from sodium formate. This relationship induced Victor to undertake production of formic acid and make more efficient use of plant in Chicago Heights. The first attempt began in 1920 and continued during the period when imports were controlled by license. It ended disastrously, however, in 1922 because of insufficient tariff protection against German producers, who

flooded the American market at cut prices, and then as soon as Victor withdrew, raised the price to the limit permitted by the market price of competing acids, such as acetic. The German monopoly lasted until 1928, when Victor began operating a small unit and was able to expand the plant substantially after Congress passed the Tariff Act of 1930, providing a duty of 3¢ per lb.

Increased productive capacity of phosphoric acid at Nashville led to quantity production of various salts, such as trisodium phosphate marketed in 1921, and manufacture of acid sodium and tetrasodium pyrophosphates was started at Chicago Heights the following year. Large-scale manufacture of dicalcium and tricalcium phosphates was undertaken in 1924, and next year production of monocalcium phosphate was transferred from Chicago Heights to Nashville, where the Company's entire requirements have since been produced. Jan. 7, 1926, a $300,000 fire destroyed the Nashville monocalcium phosphate plant and emergency operations were resumed at Chicago Heigths, while rebuilding was rushed to completion in less than 30 days.

In 1926 a product with detergent and germicidal properties was developed which had the widest use in the dairy and food industries. However, because of the special marketing needs, the Company allocated the new product, named Diversol, to its subsidiary, the Diversey Manufacturing Co., incorporated in 1923. Diversol is still marketed, but the name of the subsidiary was changed in 1931 to the Diversey Corp.

The second major change in the Company's operations occurred in 1928, when a pilot-plant blast furnace first built in 1923 at Chicago Heights finally was made to operate successfully in producing phosphoric acid. Victor had never discarded the idea of a thermal process. In 1923 Henry W. Easterwood, now chief of Victor's Patent Department, joined the Company, having spent several years at Arlington Farm, Department of Agriculture, studying the high-temperature production of phosphoric acid. In 1924 the late Harry F. Noyes, who at the time of his death was a vice-president of Victor, and Rothe Weigel, now executive vice-president, became associated with the project. These engineers brought with them essential experience in the actual operation of blast furnaces, and from then on progress was rapid. Research was conducted at Chicago Heights, where a 20-ton coke-fired blast-furnace experimental plant was erected. After four years a large-scale commercial plant was constructed at Nashville, and the furnace was first blown-in on Friday, the 13th of Feb. 1929. Within a few months modifications were made which enabled the production of elemental phosphorus in addition to phosphoric acid, and by-product ferrophosphorus. In 1930 the blast-furnace plant was enlarged to supply the Company's entire requirements of phosphoric acid and manufacture of triple superphosphate was started as an outlet for any acid produced in excess of that needed for technical phosphates, and to permit continuous operation of the blast furnace.

Broadening of the market and increased demand for phosphates led the Company to acquire its own phosphate reserves. In 1930 mineral rights of some individual properties were purchased, and in 1931 the Globe Phosphate Co. was acquired, with about 2,200 acres of middle Tennessee phosphate land. Since that time, additional properties in the same vicinity have been acquired. Thus far, only a small part of these reserves has been mined, as it has been advantageous to buy the phosphate rock from outside sources. These reserves are maintained against any contingency. To produce a fluorine-free lime for the manufacture of a purer grade of calcium phosphates, Victor research developed a patented process and constructed a kiln at Nashville, where high-quality lime is produced. To supply this kiln, a limestone deposit at Anderson, Tenn., was purchased in 1935.

Manufacturing facilities at both the Chicago Heights and Nashville plants had been expanded by 1930 to take care of increased demands for calcium phosphates, ammonium phosphates, and sodium phosphates. Disodium phosphate was first marketed by the Company in 1929, while the following year saw the first volume sale of elemental phosphorus. In 1931 Victor began manufacturing phosphoric anhydride, followed by phosphorus pentachloride, oxychloride, trichloride, and thiochloride. During 1932-36 several proprietary products were marketed, including a polymerization catalyst for the petroleum industry and some modifications of sodium metaphosphate. Aluminum formate was made for use in waterproofing compounds.

The availability of phosphoric anhydride, phosphorus chlorides, and pyrophosphoric acid stimulated interest in organic phosphorus compounds. Victor research chemists began reacting P_2O_5 with alcohols and other organic chemicals, and during the past 15 years the Company has made several hundred organic phosphorus compounds available for research and commercial uses. Among these are hexaethyl tetraphosphate and alkyl acid phosphates. The latter have been used commercially for catalysts, the polymerization of resins, and plasticizers, their esters for oil additives, sodium salts for wetting agents, and amine salts for cation-active compounds. Phosphorus thiochloride has been used in the manufacture of a nonpoisonous inhibitor for phosphoric acid, which made it possible to ship 75% phosphoric acid in steel drums. Softening agents have been used in conjunction with flameproofing agents for textiles and paper. Hexaethyl tetraphosphate and tetraethyl pyrophosphate had no apparent commercial use until recently, when their insecticidal properties were discovered.

During the middle 1930's, basic changes in the power supply of the South resulted in increased electric power available at lower rates. The blast furnace at Nashville had been enlarged three times and the increasing cost of necessary coke became a serious problem. Victor decided to build an electric-furnace plant to supplement the blast-furnace operation. In 1937 a 20-year contract for electric power was obtained from the TVA, assuring an adequate power supply for this furnace, and then 133 acres were purchased near Mt. Pleasant, Tenn., for construction of a plant to cost over $1,000,000. Financing was through the issue, late in 1937, of 75,000 additional shares of common stock, increasing equity capitalization to 696,000 shares against an authorized total of 750,000. The block of additional shares was sold to F. Eberstadt & Co., and at that time the stock was first listed on the N. Y. Stock Exchange.

The electric furnace at Mt. Pleasant came into operation June 1, 1938. Construction of two additional electric furnaces there was started in 1939 to take care of new demands for tetrasodium pyrophosphate as a soap builder and other broadening fields of consumption of phosphates. Financing was by means of loans obtained in 1939, which were retired on Oct. 15, 1941, by sale of 54,000 shares of Victor common stock. With this increase in electric-furnace capacity and with a further increase in the cost of coke, it was found advantageous to shut down the blast furnace at Nashville in 1940.

The development of chemical leavening agents having a controlled rate of reaction and superior to competitive products, continued to be one of the Company's major research projects, and in 1934 it introduced an improved, free-flowing monocalcium phosphate. 1939 brought an innovation in leaveners, with the development by Victor of a new, slow-acting monocalcium phosphate sold under the name of V-90. Victor chemists found that a certain type of heat treatment was effective on so-called favorable impurities which remained in the 85% technical phosphoric acid produced by the blast furnace. This development was of major

importance in the Company's sales to the milling industry in the preparation of self-rising flour, pancake flour, and the manufacture of household baking powders.

Anticipated increase in demand for phosphorus, in prospect of World War II, required the construction of a fourth electric furnace at Mt. Pleasant, which came into operation in Dec. 1940. Phosphorus was sold to the U. S. Government for shipment to arsenals and for lend-lease. Following Pearl Harbor, the entire phosphorus-producing capacity of the Company was at the disposal of Navy and War Departments, and phosphorus and phosphates were placed under allocation by the War Production Board. Phosphorus was essential during the defense program and throughout the war for phosphorus grenades, mortar shells, incendiary bombs, tracer bullets, and bombs for smoke screens; sodium oxalate, for airplane flares.

A new and larger plant for the production of phosphorus oxychloride, which began operating Oct. 1942, supplied large quantities of this chemical to producers of plasticizers, sulfa drugs, and Atabrine. Special lead-lined tankcars for it were completed in time to be of service when the supply of these drugs was critical. Three plants were built and operated by Victor for the Defense Plant Corp. The first two, for the production of phosphoric anhydride, were operating by Dec. 1942 and by June 1943, respectively. A large part of the P_2O_5 was shipped to the manufacturers of methyl methacrylate resins for use as plane parts. The third plant, located at Chicago Heights, was for sodium iron pyrophosphate and ferric orthophosphate, required in the production of enriched flour and bread. The authorization was approved June 1943 and the plant operated by December. During 1946 the Company completed negotiations for the purchase of all these plants.

Numerous expansions of Victor's own plants were authorized during the war. In 1943 the polymerization catalyst production at Chicago Heights was enlarged to supply increased quantities to producers of high-octane gasoline. The same year the sodium hexametaphosphate plant was enlarged and in 1944 acid sodium pyrophosphate production was increased. These expansions resulted in increased consumption of phosphorus, and in 1944 a new phosphoric acid unit was completed at Chicago Heights. Sodium tripolyphosphate, used in the manufacture of detergents, was marketed in 1940 and the plant enlarged in 1945. Tetrasodium pyrophosphate production was increased in 1945 and authorization obtained for expansion of the dicalcium phosphate plant. This plant and construction of a new warehouse at Chicago Heights were completed in 1946.

The importance of organic phosphorus compounds has increased and some of the more recent developments include: nonionic wetting agents and detergents; alkyl and aryl phosphinates and phosphonates, including clear, colorless, thermosetting, nonflammable resins; and an entirely new series of plasticizers having phosphorus-to-carbon linkages. Others are known to have commercial uses, but are not available because of the shortage of raw materials.

Soon after V-J Day, the Company decided to locate an electric-furnace plant in Florida, close to the phosphate rock deposits. A site of 106 acres was purchased north of Tarpon Springs and named Victor, Fla. Construction of the plant began in 1946. Financing for this facility and other plant expansions was accomplished early in 1946 by the issue and sale of 40,000 shares of 3½% preferred stock at $100 par. Realignment of management became effective Jan. 1, 1947, as follows: August Kochs, chairman; Walter B. Brown, president; Rothe Weigel, executive vice-president; William D. Webster, vice-president of finance and comptroller; Otto H. Raschke, vice-president, sales; Tolman G. Everett, secretary; William Pruzansky, assistant secretary. Other Company officials previously elected are: Frank A. Schwerdt, treasurer; and Harry E. Jackson, assistant treasurer.

The basic policies of Victor Chemical Works have remained the same through-

out its history, the foremost being insistence on quality production of all its products. Research has been maintained through good times and bad, and directed toward improvement of existing products as well as the development of new ones. Diversification was sought wherever practicable, but always bearing in mind that the Company's natural market is among the producers of stable consumer goods. Cost reductions over a period of time have been effected through improvement in processes and these have made possible lower selling prices, thus broadening the markets of the Company. For 50 years the Company has been under the same management and without mergers with or purchases of other companies. Today it manufactures a complete line of technical and food-grade chemicals derived from phosphorus, formic and oxalic acids and their salts, and many special chemical products. Elemental phosphorus is produced at plants located near domestic phosphate rock deposits and processed at Victor plants within easy shipping distance of principal customers producing preleavened flours, baking preparations, dentifrices, pharmaceuticals, flameproofing and metal-treatment compounds, detergents, soft drinks, textile chemical specialties, and other chemicals.

VICTORY CHEMICAL COMPANY, INC., was started Sept. 1, 1943, by a group headed by Harold D. Farber, to make titanium tetrachloride which was used as a smoke screen by the Armed Services. This product was being made in some tonnage by another company with a cyano nitrate process which was somewhat limited and expensive. Thomas A. Patterson for two years prior to the formation of the Company, had experimented with the oxide process and had it fairly well perfected to produce in large quantities at a more reasonable price. Until V-J Day, the Company produced the largest part of the product used by the Armed Forces.

When the war ended, some facilities were converted and more added toward a chlorobenzene plant to produce *p*-dichlorobenzene, monochlorobenzene, *o*-dichlorobenzene, and muriatic acid, continuing to maintain most of the Company facilities for titanium tetrachloride though not producing at present. Victory Chemical is also making *p*-nitroaniline which is being converted to *p*-phenylenediamine.

The directors are Harold D. Farber, president, Simon Farber, vice-president, and Thomas A. Patterson, treasurer. The secretary of the Company is V. Mason.

VISKING CORPORATION is the outgrowth of a fellowship established at the Mellon Institute of Industrial Research in 1916 by Erwin O. Freund, late president of the Corporation, after seven years of his own personal research to produce a synthetic sausage casing. The fellowship continued until 1925 with Clarence Weirich, the first incumbent (1½ years), Frank Stockton, the second (1 year), and William F. Henderson, the third. Later, Harold E. Dietrich was added.

Each fellow concluded that cellulose was the most promising material with which to imitate the properties of animal sausage casings. It remained for Henderson and Dietrich to develop and perfect viscose solutions and extrusion equipment which would produce thin-walled, seamless tubing of adequate strength. The concept of impregnating the tubing with glycerin and subsequently drying it while inflated in a restraining tube, carried the research to a point where commercial exploitation became possible.

The Company's incorporation as the Visking Corporation, "visk" from viscose and "ing" from casing, was in 1925, and in Jan. 1926 a plant was established in the Union Stock Yards, Chicago. The first shipment of casings was to a packing

house in Pittsburgh. Everything went well until the frankfurters came out of the smokehouse. They hung loose, baggy and were full of water pockets. But when cut apart, the meat was firm, fine in appearance, and practically slid out of the casing. Thus was born the frankfurter. Many difficulties still remained, but one by one they were eliminated. Continuing research brought forth new cellulose casings for packaging bologna, salami, cervelat, and many other varieties of sausage, as well as meat loaves of all descriptions. Unlike the frankfurter casings, these remain on the product and are imprinted in one or more colors with the maker's brand name and trade-mark.

Further research resulted in many new items, principally Visqueen, a plastic film from which are made shower curtains, capes, refrigerator bowl covers, and many other protective coverings. The widest plastic sheet ever produced is made by the Visking method.

Company plants are located in Chicago, Terre Haute, and North Little Rock. The last location is producing a new nonwoven fabric from cotton and/or rayon, known as Viskon, which has numerous industrial and consumer applications in many fields unrelated to the packing industry.

VULCAN COPPER & SUPPLY COMPANY was founded in 1901 as the Vulcan Copper Works Co. to manufacture distilling apparatus for "distilleries, vinegar plants, chemical laboratories, and other process industries." The original company was a partnership with H. O. Wentworth as the principal partner and president, in which capacity he served until his decease in 1941. In 1908 a mill supply business was established by the same principals, but the two companies operated independently until 1921, when they merged and incorporated as the Vulcan Copper & Supply Co. In its early years the Company was largely identified with the alcohol industry. With this experience in the processing field, it was only natural to become identified with the rapidly expanding chemical industry during World War I.

Vulcan's entry into the process engineering field dates from 1928 when its present head, T. O. Wentworth, set up the research and development laboratory and organized a staff of chemical and mechanical engineers. This group at first specialized in problems associated with the production of acetic acid and processes for the concentration of the lower aliphatic acids, notably acetic, from aqueous solutions. By the middle 1930's the chemical engineering phase of Vulcan's operations had grown to such a degree that complete chemical plants were being designed and built. Vulcan is now capable of providing complete service, including research and development work, process and mechanical design, shop fabrication, field erection, and initial operation. During World War II it made significant contributions to the production of synthetic rubber, ethyl alcohol, smokeless powder, and special projects for the Chemical Warfare Service.

In 1947 a Canadian subsidiary, with headquarters in Montreal, was formed jointly with Canadian Vickers, Ltd., of Montreal, known as Vickers-Vulcan Process Engineering Co., Ltd., to provide chemical engineering services to Canada.

The board of directors of the Vulcan Copper & Supply Co. at present (1948) are: T. O. Wentworth, P. W. Wentworth, Thomas Carroll, E. G. Kahle, and E. E. Wentworth. The offiers are: T. O. Wentworth, president and general manager; Carroll, vice-president and assistant general manager; E. E. Wentworth, treasurer; P. W. Wentworth, secretary; and Ronald Jeanmougin, assistant secretary.

WILLIAM R. WARNER AND COMPANY, INC., had its start with the opening of a retail drugstore in Philadelphia at Second St. and Girard Ave. in 1856. The founder, William Richard Warner, then newly graduated from the Philadelphia College of Pharmacy, had completed a lecture tour through Pennsylvania, speaking on "combustion of gases, burning of ice, and administration of laughing gas." He had acquired his first knowledge of drugs by working as chore boy in a drugstore in Easton, Md., while a student at Easton Academy. Showing a keen interest in science, when he was only 18 years of age he became a correspondent of Louis Agassiz of Harvard and Spencer Baird of the Smithsonian Institution.

Warner's drugstore prospered, so that in 1866 he decided to establish a manufacturing and wholesale business on N. Third St. There he began to develop specialties and to prepare standard tinctures and elixirs. He took an active interest in the Philadelphia College of Pharmacy and was a member of the committee for the revision of the U. S. Pharmacopoeia. William Warner was a man of ideas and practical ability that enabled him, for example, to develop a manufacturing process for the sugar-coated pill, a significant step in modern pharmacy.

Among his preparations were Hinkle's Pills, a laxative prescription of a practicing physician, and Parvules, minute sugar pills containing small doses of drugs for frequent administration. The Warner medicinal specialties enjoyed so wide a professional acceptance, both the manufacturing and the wholesale business expanded rapidly. To provide additional space, a six-story building was purchased at 1228 Market St. and became Warner headquarters in 1876, the year of the Centennial Exposition. Wisely foreseeing the influx of thousands of visitors to Philadelphia, Warner equipped and stocked the first floor as a retail drugstore where trustworthy drugs and medicines could be bought at fair prices. This venture proved to be successful but the quarters were inadequate and 10 years later Warner Hall was erected at Broad and Wallace Sts., popularly known as 649 N. Broad St. The building was the best construction of the time, equipped with passenger and freight elevators, boilers for generating steam and power, and an engine and dynamo for incandescent lighting throughout. The manufacturing facilities were moved to the new building, but the general offices and the retail stores continued at Market St.

Then came the disastrous fire in the spring of 1899. Practically all buildings on the south side of the 1200 block on Market St. were destroyed. The Warner retail store was wiped out, and no attempt was made to reestablish this part of the business. Manufacturing and jobbing were quickly reorganized and transferred to 649 N. Broad St.

Warner traveled widely and established contacts with Francis Newbury & Sons, Ltd., of London, for sale of Warner products in England and India. Sales offices were also set up in New York and Chicago and Warner fluidextracts, sirups, tinctures, and medicinal wines, as well as the sugar and gelatin-covered pills, became standard items.

Warner was among the first to promote drug preparations to physicians and to advertise in medical journals. In 1888 he published the first issue of *Warner's Therapeutic Reference Book* which was given to physicians. In addition to descriptions of the Company's products, the book contained a formulary, tables of weights and measures and of poisons and antidotes, a posological table, and directions for postmortems. It was a valuable addition to many a medical practitioner's then meager library.

At Warner's death in 1901, control passed to the eldest of his three sons,

William R. Warner, Jr., who operated the business until 1908. Then the entire assets were purchased by Henry and Gustavus A. Pfeiffer and the Company was incorporated in Pennsylvania. The first board of directors consisted of Henry and Gustavus A. Pfeiffer, and William R. Warner, Jr.

The Pfeiffer brothers already had a flourishing drug concern in St. Louis. Starting as an apprentice in the Corner Drug Store in Cedar Falls, Ia., Henry Pfeiffer had studied pharmacy and passed the examinations which enabled him to fill prescriptions and operate a drugstore. He then purchased the Corner Drug Store and, after about 10 years' successful operation, began manufacturing drug specialties and household remedies. With a partner he organized the Allan, Pfeiffer Chemical Co. in St. Louis, in 1891. Nine years later Henry Pfeiffer sold his interest in the firm, and in Mar. 1901 organized the Pfeiffer Chemical Co. with his brothers Paul M., who later retired, and Gustavus as partners. With new machines but few customers, the company opened business in an empty building on the levee in St. Louis; with initiative and hard work, it grew and prospered.

With headquarters at 649 N. Broad St., Philadelphia, the first important action of the new owners of Warner was to discontinue the wholesale business and devote all efforts to pharmaceutical preparations and medicinal specialties. Manufacturing operations and distribution activities were continued both in St. Louis and Philadelphia, but in 1916 the business offices, laboratories, and manufacturing facilities at Philadelphia were moved to the present location in N. Y. City, the original site of the Altman Store at Sixth Ave. and 18th St. That year the well-known cosmetic firm of Richard Hudnut, established in 1888, was acquired and its products expanded. The St. Louis plant was also enlarged.

Throughout the years a number of concerns have been acquired and operated as affiliates or subsidiaries: Dr. Earl Sloan (1914), Waterbury Chemical Co. (1929), Nonspi Co. (1930), Chamberlain Medicine Co. (1930), Schering & Glatz, Inc. (1930), Vince Laboratories (1932), and Marcy Co. (1935). In 1920 the original Pennsylvania corporation was dissolved and Warner was reincorporated in Delaware.

Warner's export sales having expanded rapidly since the founder established connections with Newbury & Sons in England, the Company eventually decided to establish Company-owned branches and manufacturing facilities in other countries better to serve certain markets. The first in operation was a wholly owned subsidiary at Buenos Aires in Apr. 1922. The immediate success of this branch encouraged the Company to establish branches in other countries, so that at the outbreak of World War II there were 20 in full operation. At the present time 14 of these branches are in successful operation. In addition, most of the remaining countries of the world are covered by 70 sales agents and, in some cases, local manufacturing is engaged in, with the Company maintaining its own special representatives.

Henry Pfeiffer served as president until his death in 1938, at the age of 82. He was succeeded by his brother G. A. Pfeiffer, who had been general manager many years. Under the latter, the Company kept in step with the progress in medical science. Preparations were begun in 1938 to engage in research for the improvement and development of medicinal preparations. To achieve this aim of "service through research," the Warner Institute for Therapeutic Research was established in N. Y. City. Equipment was increased and the staff enlarged for research in chemistry, pharmacology, toxicology, pathology, biochemistry, bacteriology, nutrition, and pharmacy. Additional scope to this work is provided by research fellowships in hospitals and other scientific institutions, and scholarships in medical colleges. In 1943 a third plant was opened for research and manufacture in Mamaroneck, N. Y., to supplement the operations in N. Y. City.

Oct. 1943, Warner announced that it would henceforth confine its operations to ethical medicinal specialties. A subsidiary corporation, Standard Laboratories, Inc., was set up to handle the proprietary products of 13 subsidiary companies.

In Dec. 1945, G. A. Pfeiffer announced his retirement from active business and Elmer H. Bobst became president and general director. Bobst had been acquainted with the Pfeiffers ever since he sold chemicals in Philadelphia in 1912, and had but recently retired as president and managing director of Hoffmann-La Roche, Inc., Nutley, N. J., with which he was associated some 30 years. On assuming the direction of Warner, Bobst announced a broadening of the scope of the Warner Institute in developing new remedies, improving existing medicinal preparations, and the pooling of pharmaceutical research by several pharmaceutical and chemical manufacturing firms here and abroad.

A few months later (May 1946), the Company announced discontinuance of all standard pharmaceuticals and galenicals, elixirs, tinctures, sirups, pills, and tablets, in order that all research and production facilities might be devoted to the development, manufacture, and distribution of ethical medicinal chemicals and pharmaceutical preparations. In the cosmetic field, however, the Company's affiliate, Hudnut, expanded in 1946 by acquiring several new lines of cosmetics.

The present board of directors is composed of G. A. Pfeiffer, Louise P. Pfeiffer, Elmer H. Bobst, Leslie A. Klein, M. G. Herold, C. A. Pennock, J. M. Leach, D. A. Walker, and R. J. Davis.

WEST END CHEMICAL COMPANY was organized Feb. 26, 1920, as a California corporation. It is an offspring of West End Consolidated Mining Co. of Tonopah, Nev., started in 1915 by F. M. Smith, more generally known as "Borax Smith." It was Smith who first discovered borax on Teals Marsh, Nev., and later developed the borax industry with its world-wide properties and operations, including the widely known Death Valley operations where the famous 20 Mule Team was first used. In 1918 West End Consolidated secured a lease from the Government on certain acreage of Searles Lake, Calif., a dry lake containing large quantities of borax and soda originally discovered by John Searles about 1862. In 1921 it purchased the largest known single deposit of colemanite (crude borax ore) in the world, located in Clark County, Nev.

Stock of West End Chemical Co. was originally owned 100% by West End Consolidated Mining Co., having been received by it in exchange for the Searles Lake lease and title to the Clark County colemanite mine. Thus a new borax and chemical industry was launched, sponsored by the pioneer operator in borax, F. M. Smith. Stock of West End Chemical was subsequently distributed by West End Consolidated to its stockholders as a dividend and the two companies went their respective ways independently.

Operations at the Clark County property were carried on many years and many thousands of tons of borax were mined. Later, when other ore of a purer grade was discovered and successful processes of recovering borax and soda at Searles Lake developed, it became necessary to shut down the Clark County property. West End Chemical Co. has been operating successfully at Searles Lake since 1929, producing borax and soda ash.

Starting in a small way, the Company's production has grown to where it now ranks high among the producers of borax and soda ash on the Pacific Coast. The Company's plant and process have been under constant improvement. In 1942 major expansion involving $750,000 was completed in order that the heavily increasing demands of the market might be met. This demand has continued to increase so rapidly that major expansions have had to be undertaken each year

to the extent of about $1,500,000 in the last five years. The plant is still being expanded.

The original board of directors and officers of the Company were: F. M. Smith, president; J. F. Carlston, vice-president; George C. Ellis, secretary; C. P. Murdock, R. P. Jennings, R. L. Oliver, and L. W. Bennett, directors. Smith, with the assistance of J. W. Sherwin as general manager and H. D. Hellmers as chief chemist, carried the management of the Company until he died in 1931. In 1925 J. R. Blair and Norman P. Ellis became directors to fill the vacancies created by previous resignations of Carlston and Jennings. In 1928 J. W. Sherwin replaced Bennett as director and in 1930 Mrs. Evelyn Ellis Smith was elected by the stockholders to the board and on her husband's death, assumed the presidency. In 1933 Sherwin died and Hellmers assumed the technical management of plant operations and Blair, the Sales Department. In 1933 H. D. Budelman of Tonopah was elected to the board to fill the vacancy caused by Sherwin's death.

Mrs. Smith carried on as president until 1943, when she was made chairman of the board, and George C. Ellis, who had many years' experience in the borax industry prior to the organization of West End Chemical, was elected to the presidency. During 1933-47, several changes in the board took place, resulting in the present board of: Mrs. Evelyn Ellis Smith, chairman; George C. Ellis, president; J. R. Blair, vice-president and treasurer; Norman P. Ellis, secretary; F. W. Wieder, director (vice-president, Stauffer Chemical Co.); F. G. Stevenot, director (president, Puget Sound Pulp & Paper Co.); and H. D. Budelman, director (vice-president, West End Consolidated Mines Co.).

The Company's executive office is located in the Latham Square Bldg., Oakland, Calif., and the operating plant is at Westend, San Bernardino County, Calif.

WEST VIRGINIA PULP AND PAPER COMPANY became aware of the potentialities of "waste conservation" early in its history, and in about a half century intensive research and development in this direction have placed the Company high in the field of chemical by-products manufacturing. This role has been strengthened considerably by its constant efforts to reduce the effluents entering the streams from its six pulp and paper mills at Luke, Md., Tyrone, Pa., Williamsburg, Pa., Covington, Va., Mechanicville, N. Y., and Charleston, S. C. The program has been broadened to embrace methods for even greater recovery of the wood log, which represents the industry's prime raw material. A loss of about 50% of the log is estimated in the cooking process which transforms wood chips into pulp. The resulting liquor contains valuable chemicals, many of which are now being extracted. The ultimate goal is complete utilization of the wood.

The Company's chemical business today is conducted by Industrial Chemical Sales Division, with main offices at 230 Park Ave., N. Y. City. The Division markets 16 major chemical products derived from wood: activated carbon, precipitated calcium carbonate, tall oil, abietic acid, chlorine, wood turpentine, liquid caustic soda, lignin, and cellulose fibers. Sales offices are maintained in New York, Chicago, Cleveland, and Philadelphia.

The Company's entrance in the chemical field came in 1898, 10 years after its first pulp and paper plant was founded at a site now known as Luke, Md. Patents were acquired for the recovery of CO_2 gas and the manufacture of calcium sulfate from waste lime derived from the causticizing (soda pulp) process. The Alba Chemical Co. was organized and a plant was attached to the Tyrone mill.

The Company's second step in chemicals was in 1910, when it collaborated with the Robeson Process Co. in the installation of a plant and process at its Covington mill for the utilization of waste sulfite liquor. About this time a thorough study

of its opportunities in the chemical by-products manufacturing field was undertaken and a subsidiary, Industrial Chemical Co., was incorporated in New York State, July 1911, and began business Feb. 1912.

The Industrial Chemical Co. took over the operations of the Alba Chemical Co., established a research laboratory in New York, and began the great expansion program which resulted in the extensive operations of today. A new whiting plant was built at Tyrone and a very substantial market was established for Alba whiting. Later a recovery method embracing the reburning of waste lime to permit it to be recycled through the process made the older whiting process obsolete. The new recovery process now operates in five of the Company's six plants.

For years the Company has been producing chlorine and soda for its own use. This operation dates back to 1905 when an exclusive license was obtained to operate the English Hargreaves-Bird process in the United States. Today electrolytic plants are operated by all the Company's mills to meet the chlorine and soda needs. It was the installation of the first electrolytic plant in Luke, Md., in 1906, however, which brought one of the first products originated by the then-new Industrial Chemical Co.—precipitated chalk. An excess of drying capacity and some excess CO_2 gas brought about the manufacture of a precipitated calcium carbonate of a quality suitable for dentifrices, cosmetics, and drugs. The first chalk plant was started at the Luke plant in the summer of 1912. Pioneering work was done to introduce this fine white powder as a filler in paper, but not until 1932 was it found advantageous to produce and use large tonnages of precipitated chalk for particular grades of paper. As the uses of precipitated chalk multiplied, customers became insistent on quality standards to meet all the requirements of the Pure Food & Drugs Law and the U. S. Pharmacopoeia. As a result, an improved process was developed and operations were started in Covington, in 1928.

Following a visit to Sweden in 1911 by John G. Luke and Thomas Luke, officers of the Company, the Company secured the American rights to the Ekström process of producing ethyl alcohol from waste sulfite liquor, and the first such distillery in America was installed in the Mechanicville plant in 1914. It operated intermittently for many years, but finding it difficult to compete with alcohol made from cheap molasses, finally closed down in 1940.

Arising out of disposal of leacher waste or black ash at its Tyrone plant, the Company became pioneer manufacturer in this country of activated carbon. Following marketing research, the initial experiments took place in the New York research laboratory in June 1913, and next year transferred to Tyrone, where manufacture on a semicommercial scale was undertaken. The first product was given the trade name of Superfiltchar in 1917-18. In 1923 the name was changed to Nuchar and Suchar. In the late 1920's there was considerable difficulty throughout the country in providing drinking water that was palatable, a situation emphasized by a drought. A finely powdered carbon, Aqua Nuchar, was offered for this purpose. It proved so effective that today more than 1,200 water plants in this country, Canada, and other parts of the world are controlling objectionable tastes and odors with it.

As the business grew and all leacher waste available at both the Tyrone and Williamsburg plants was used up, it was necessary to expand. A second carbon plant began operations at Luke in 1930, and a third at Covington. Since starting, the Covington plant has twice expanded its facilities and improved processes have been developed to meet the quality requirements of large consuming industries. In addition to the three carbon-manufacturing plants, a carbon research center is maintained at Tyrone, where more refined grades of the product are being developed. The Tyrone Research Department was responsible for the widespread

use of activated carbon in penicillin, streptomycin, and other pharmaceuticals. Today West Virginia Pulp & Paper Co. is the only manufacturer in the world of activated carbon as a product of pulp production.

To utilize waste bark from spruce and hemlock wood, a plant was completed at Cass, W. Va., in 1915, to manufacture tanning extracts on a large scale. Incidental to these operations, large quantities of the yellow dyewood extract, osage orange, were produced and used to replace the foreign fustic extract for dyeing khaki cloth during World War I. This plant operated successfully until the advent of the automobile diminished the demand for tanned leather. The plant was closed down in 1928.

In 1916, following research by Dr. Viggo Drewsen, a leading authority in the pulp and paper industry who first became associated with the Company in 1894, a small semicommercial plant was erected at the Luke mill for extracting acetone, wood alcohol, and other solvents from Calignate, treated waste liquors from the soda pulp digesters impregnated with lime. While this work was in progress, a serious shortage of acetone for the manufacture of cordite occurred, and the British Government prevailed upon the Company to erect a full-scale plant which started operations a few months before Armistice Day. Because of sharply reduced demand and accumulated reserve stocks of acetone, the plant was liquidated after the war.

More recent developments include the utilization of by-products from the cooking of slashpine, from which kraft paper and board is made. From this waste are derived Liqro and Indusoil, crude and refined grades of tall oil; Tallex, abietic acid crystals; and Tallene, a pitch product. Substantial quantities of wood turpentine also are recovered from the sulfate process of pulping pine woods. Terpene base products now being produced on a commercial scale in a modern fractionation plant at Charleston, include α-pinene, β-pinene, dipentene, and pine oil.

Under the trade name Indulin, the Company is now marketing lignin on a small-scale commercial basis. Indulin is derived from pine wood used in the sulfate pulping process. It has a promising industrial application as a reinforcing pigment for synthetic and natural rubbers. About 500 lb. of lignin can be obtained from a ton of pulp, and it is estimated that the South can yield more than 1,000,000 tons of lignin annually. Another new chemical development is Polycel, a chemically treated wood cellulose fiber available in various fiber lengths in unbleached, bleached, and colored grades. It was developed in 1943-44, when the Company began intensive research on uses of pulp other than paper.

Much of the developement program today is carried on in the Development Department at Charleston, which began operations in 1941, following the closing of the N. Y. City research laboratory, and which operates pilot plants in connection with the chemical by-products of the Company.

WESTERN PRECIPITATION CORPORATION was set up in 1907 as the engineering company, Western Precipitation Co., to operate under exclusive license of the Cottrell precipitation patents, in California. Frederick Gardner Cottrell conducted his first experiments on electrical precipitation in 1906 while he was professor of physical chemistry at the University of California. The immediate incentive was the problem of arsenic poisoning of the catalyst at the sulfuric acid works of E. I. du Pont de Nemours, at Pinole on San Francisco Bay, coupled with the urge to augment his meager professional salary. He remembered the futile attempt of Sir Oliver Lodge to dissipate the fogs of Liverpool by electric means, and assembled some crude equipment available at the University laboratory, made a synchronous rectifier by hand out of a small electric fan, observed

the discharge effects in the dark while working late at night, and quickly deduced the fundamental requirements of the process which has since played such an important role in the chemical industry. He soon had a small pilot plant working at the du Pont works, in which he removed the arsenic from the gases by successive sulfuric acid fume formation and electrically precipitating these successive acid mists with their entrained arsenic. Curiously this successive fume formation for removing arsenic was never used commercially, although it was the basis for one of Cottrell's very early patents.

When information of these experiments at Pinole came out, American Smelting & Refining Co. brought Cottrell the critical problem at its Selby smelter, where a serious lawsuit was in progress over the alleged damage caused by the fumes escaping from the kettles in which the gold and silver were parted by boiling sulfuric acid. Cottrell transferred his activities to this more pressing problem and with the assistance of a former student, Herbert A. Burns, designed a successful commercial installation which went into operation in 1907 and which, with minor repairs and alterations, has been in successful commercial operation these intervening 40 years.

Cottrell by this time knew that he had a process of value, assuming that adequate patent coverage could be obtained. So he approached Harry E. Miller, a University of California alumnus in chemistry and a man of modest means. Miller in turn approached his banker friend, E. S. Heller, another alumnus, and the three, with Prof. Edmond O'Neill, head of the University's Chemistry Department, organized a small company to undertake commercial development of the process and release Cottrell for his academic work which was still his first choice. At Heller's suggestion, the International Precipitation Co. was set up as a patent-holding company; Western Precipitation as the operating company. The plan was to organize other companies similar to Western Precipitation in other restricted districts, but this program fell of its own weight because of the engineering complexity of the business. Both International and Western Precipitation were chartered in California in 1907, each with an authorized capital of $20,000, but considerably less than this was actually issued. Several years later the entire setup was reversed and International, as the patent-holding company, became the wholly owned subsidiary of Western.

Heller became president of both newly formed companies; Cottrell, vice-president; Miller, secretary-treasurer; and O'Neill, the fourth director. Cottrell was technical director, dividing his time between the Company and the University, and Herbert A. Burns was the only full-time employee. Miller devoted such of his time as was necessary to keep the corporation records and Agnes Cole was part-time stenographer. Cottrell and Burns carried the work at Selby to the treatment of the roaster gases, but the precipitation of these fumes of mixed metallic compounds proved to be more difficult and the work continued for over a year with inconclusive commercial results.

In the meanwhile, in 1908, Buckner Speed joined Cottrell on the somewhat closely related problem of taking water droplets out of oil. Some of the University faculty members had invested their sparse savings in the Lucile oil lease in the rich Coalinga field, but their lease produced an unsalable oil-water emulsion which would not break or separate on standing or simple treatment. In fear of losing their entire investment, they persuaded Cottrell, through Speed, to apply his electrical process to these emulsions. Through his unusual ingenuity, Speed soon had a commercial unit in operation and thus saved the Lucile Oil Co. and incidentally he, with Cottrell, established a completely new process, later covered by entirely separate patents, as the breaking of liquid emulsions had no similarity or relation to the separation of suspended particles from gases.

The fume work had been carried to the Balaklala smelter in northern California, where the zinc oxide-laden fumes did not respond to treatment as did the acid-laden fumes at Selby smelter, and the oil work was carried to the Santa Maria oil field, where the tight emulsions did not respond to the same treatment that was effective at the Lucile lease. Extended research on both processes was an obvious necessity and the finances of the Company could not stand any long program without income or refinancing. At this time, 1909, Allen C. Wright, a friend of Cottrell's in the Mechanical Engineering Department of the University of California, and Walter A. Schmidt, a former student of Cottrell's, joined the staff of the Company. During the following year they devoted their entire time to the oil dehydration problem at Santa Maria, while Cottrell and Burns attacked the fume precipitation problem at Balaklala. Finances did not improve and in 1910 the Company sold the oil dehydration rights to the Petroleum Rectifying Co., organized for that purpose by Wright with the financial backing of Balfour Guthrie Co. This company subsequently built up an international business on the Cottrell-Speed electrical oil dehydration patents.

After the oil dehydration patents were sold, Schmidt transferred his efforts to a new problem that had sprung up. The Riverside Portland Cement Co. at Riverside, Calif., was involved in injunction proceedings because of the cement kiln dust that was settling upon the near-by orange groves, and it solicited the aid of Cottrell in recovering this lime and cement dust from the hot kiln gases. As the problem was so very different, Schmidt restudied the precipitation process from scratch with this particular application in view, and by the summer of 1912 the first large commercially successful installation was in operation. This handled 1,000,000 cu. ft. of gas per minute at 900° F. and collected 100 tons of dust per day at a collection efficiency of 96%. This installation is still in operation and during the intervening 35 years it has probably collected more than a million tons of dust.

Although the large precipitator installed at the Balaklala smelter to collect the fumes was fairly successful, it became evident that the main damage was due to sulfur dioxide, which could not be collected by the Cottrell process or any other known device. Therefore the smelter closed down in 1911 and copper mining operations in that district were discontinued. However, R. B. Rathbun, the smelting company's electrical engineer, carried the work on the precipitation of smelter fumes to the Garfield smelter of the American Smelting & Refining Co. and remained in charge of its Electrical Precipitation Department for 30 years.

By this time Cottrell had decided to devote all of his time to scientific work. He received an invitation from Dr. Holmes, director, U. S. Bureau of Mines, to join his staff and serve on the Government's Smelter Smoke Commission. Cottrell accepted and withdrew from active work with the Western Precipitation Co. As Heller, Miller, and O'Neill were by this time assured of getting their original investment back with reasonable profit, Cottrell prevailed upon them to accept an offer from Schmidt to purchase the exclusive rights to the electrical precipitation process in the six Western states and to the Portland cement industry throughout the United States on a deferred installment payment basis, the assumption being that these payments could be earned from the business. He also prevailed upon them to give the balance of the United States rights to an appropriate institution to serve as a foundation for the furtherance of scientific research in universities and as an agency to administer patents arising in universities. The offer was made to the Smithsonian Institution. The Regents looked favorably upon the idea, but as the Institution had no machinery for the administration of patent rights, a completely separate and independent nonprofit corporation was established. Dr.

Charles D. Walcott, then secretary of Smithsonian, and Dr. Cottrell got together a group of public-spirited men interested in the project, who collectively put up the few thousand dollars required to start the venture. They organized the Research Corp. under the laws of New York. International Precipitation thereupon, in 1912, conveyed to Research Corp. as a gift the exclusive rights to the Cottrell electrical precipitation process throughout the United States, except for the six Western states and the cement industry throughout the country.

Schmidt by this time had gotten his work started in the West. He was joined financially by his brother, Arthur A. Schmidt, and his friend, Henry M. Mosher, and technically by Herbert A. Burns and his college roommate, G. A. Witte. They acquired the shares of Western Precipitation Co. and negotiated the purchase of International Precipitation Co. The capital structure of Western Precipitation was changed in 1913 to give an authorized capital of $300,000, but only $165,000 was issued and the rights previously acquired by Schmidt were transferred to the Company in exchange for stock. Company headquarters were moved from San Francisco to Los Angeles. In 1915 Western Precipitation absorbed International Precipitation which since then has served as a wholly owned patent-holding company. In 1935 Western organized the Precipitation Co. of Canada, Ltd., as a wholly owned subsidiary.

The technical staff grew rapidly after 1913. Dr. Harry W. Morse, who joined in 1913 as chemical director, served in that capacity through the early critical years, and Evald Anderson, who joined in 1913, later served as technical director until his death in 1941. He above all others contributed most bountifully to the art of electrical precipitation. Harry V. Welch, George H. Horne, and Arthur P. Knight also contributed much to the early work. All were but part of a splendid cooperative group that worked so admirably together to solve many problems.

In 1913 Walter Schmidt went to Europe and made commercial arrangements with the sons of two pioneer investigators of electrical precipitation. They were Lionel Lodge, the son of Sir Oliver Lodge, in England, and Erwin Moeller, the son of Dr. Karl Moeller, in Germany, leading to the eventual formation of Lodge-Cottrell, Ltd., of Birmingham and London, and the Lurgi Apparatebau Gesellschaft, a subsidiary of the Metallgesellschaft of Frankfurt, Germany. Until the outbreak of World War II, the International Precipitation Co. served as clearing house for all technical developments, improvements, and experiences between Western Precipitation, Research Corp., Lodge-Cottrell, and Lurgi Apparatebau. This was very helpful to all, as well as for the public. However, as a result of the war and a consent decree entered into with the Government in 1946, all agreements have been canceled and Western, with its two wholly owned subsidiaries, International and Precipitation Co. of Canada, forms a completely independent unit, doing a nation-wide and world-wide business.

During its 40 years, Western Precipitation Co. has pioneered many problems, mostly tied into gas purification or fume recovery: by-product potash recovery in the cement industry during World War I, chloridizing voltilization of metals from complex ores, production of anhydrous aluminum chloride by volatilization, production of highly active zinc dust by controlled condensation, multiple Cyclone dust collector for high-efficiency dust collection, and various applications of spray drying and dispersion drying, particularly in the chemical industry.

In 1936 Western Precipitation Co. was reorganized without change of ownership and became the Western Precipitation Corp., International Precipitation and Precipitation of Canada continuing as wholly owned subsidiaries. Headquarters have been continuously at 1016 W. 9th St., Los Angeles, since 1913. District offices are maintained at San Francisco, Chicago, New York, and Montreal.

Neither management nor principal ownership has changed since 1911. Walter A. Schmidt has been president and general manager throughout this period. Alfred W. Knight has been vice-president since 1938 and A. Buford Reamer, secretary-treasurer since 1936. The remaining directors are Harry V. Welch (1923), Clive W. Johnson (1940), Richard F. O'Mara (1944), and W. Malcolm Schmidt (1946).

WESTVACO CHLORINE PRODUCTS CORPORATION'S history begins with Dr. Lucien C. Warner, who in 1886 became interested in the large deposits of phosphate-bearing rock on Grand Connetable Island, off the coast of French Guiana. To commercialize this interest, he retired from his business and formed the Warner Chemical Co. with a plant on the Harlem River where the necessary research was conducted. Here the first successful method of manufacturing trisodium phosphate in this country was developed. To reduce transportation costs of the raw rock, Dr. Warner and his son, Franklin H. Warner, built a plant at Carteret, N. J., in 1900, for the commercial production of trisodium and disodium phosphates.

At approximately this same time, William D. Patten had discovered the advantage of using acid sodium pyrophosphate as the leavening ingredient of commercial baking powders. To find a manufacturing source for this new product, he approached Dr. Warner and together they formed the Monarch Chemical Co. which compounded and sold baking powder and baking cream containing acid sodium pyrophosphate produced by Warner. With the protection of Patten's basic patents, Warner became the first and sole producer of pyrophosphate in the world and in large measure this product was responsible for the continued growth of the Company.

In 1902 Warner Chemical Co. purchased the Chesco Chemical Co. of Byers, Pa., which manufactured various chlorinated compounds. These products stimulated interest in production of chlorine and in 1906 a McDonald type of electrolytic cell went into commercial operation at Carteret. Over a period of years, improvements were made in the electrolysis of sodium chloride, using more modernized equipment like the Nelson and Vorce cells. The reputation of Warner as a chlorine producer became so well established that ultimately plant installations were made throughout the world, employing knowledge and equipment developed by Warner through an Engineering Department established to commercialize this unique knowledge. Low-cost chlorine produced at Carteret led to the manufacture of sulfur monochloride and carbon tetrachloride in 1906 and 1908, and to the development of a process for sodium hypochlorite used as a commerical bleach. By this time, continuing research in the phosphate field added acid calcium phosphate to Warner's growing list of commercial products. In 1912 phosphoric acid in various forms was also produced for sale.

In 1915 Ernest C. Klipstein approached Dr. Warner to buy relatively large quantities of carbon tetrachloride which he intended to merchandise as a household spotting fluid under the name of Carbona. Klipstein also had chemical manufacturing operations which required caustic soda for sulfur black and chlorine for anthraquinone. A joint venture called the Warner-Klipstein Chemical Co. came into being with a plant at South Charleston, W. Va., located near natural salt brines and coal mines. The chlorine was used for carbon tetrachloride and other Klipstein and Warner products, while the caustic soda was sold to Cincinnati soapmakers. Since carbon bisulfide was required for carbon tetrachloride, it was also manufactured at South Charleston and surplus was sold to the growing rayon industry.

The Warner Chemical Co. was of course intensely interested in better and cheaper ways to make chlorine and its research resulted in lowering costs and expanding production at South Charleston. During the First World War an electrolytic chlorine plant was constructed by Warner for the Chemical Warfare Service at Edgewood, Md. This plant approximately doubled the chlorine capacity of the United States and was probably the largest installation in the world.

In 1925 Dr. Lucien C. Warner died and in 1928 the various Warner Chemical Co. interests were consolidated into Westvaco Chlorine Products Corp., which had earlier taken over the Klipstein interests, since by that time the West Virginia operation had become larger and more important than the original Carteret phosphate plant. In 1929 United Chemicals, Inc., was formed through public financing to facilitate expansion of Westvaco through the acquisition of small chemical companies. William B. Thom, treasurer of the old Warner Chemical Co., became president of both Westvaco and United Chemicals.

In 1929 United Chemicals purchased the Monarch Chemical Co. and the Curtin-Howe Corp., manufacturers of wood preservatives. It also bought the majority of the stock of Barium Products, Ltd., Californian manufacturers of barium salts. Growth of hydrogen peroxide consumption led to the production of this chemical from barium peroxide at the California plant and later at Carteret.

In 1930 United Chemicals acquired a substantial interest in the California Chemical Co., producers of magnesium oxide from natural mined magnesite, which found a market in specialty cements and high-grade refractories. An intensive research program developed a method of producing magnesium oxide from sea water and in this process ethylene dibromide and bromine also came to be made. By 1937 the research work was completed and a large plant was built at Newark on San Francisco Bay, where production began. Since that time the major portion of the raw materials for magnesium oxide comes from the sea.

During these years Westvaco Chlorine Products Corp. began producing a synthetic hydrous magnesium silicate at West Virginia under a patented process. This unique product was called Magnesol and over the years has continued to develop as a clarifying agent wherever liquid media are used in industry.

Research continued at the Carteret phosphate plant and a number of new products, including anhydrous and crystalline tetrasodium pyrophosphate, liquid disodium phosphate, and sodium tripolyphosphate, were added. Shortly following the acquisition of the two Western units, the Carteret plant was expanded to use some of their products. Hydrogen peroxide and blanc fixe were made from Barium Products, Ltd.'s barium peroxide and Epsom salt from California Chemical Co.'s magnesium oxide. Westvaco's South Charleston plant also began to produce ethylene dibromide which was pioneered by the California Chemical Co. In the early 1930's, too, the Technical Department of Westvaco Chlorine Products started an expansion program. Two of the early developments resulted in commercial production of trichloroethylene and caustic potash.

By 1944 the original program for United Chemicals, Inc., had been completed and the subsidiaries that had been acquired over the years have since been purchased by Westvaco Chlorine Products. Thus, all of the manufacturing operations were consolidated in one operating company.

When the Second World War broke out, Westvaco was well qualified by experience and diversity to make an immediate and effective contribution to the Armed Forces. Besides supplying many important chemicals which were already normal products of manufacture, new plants were speedily constructed to supply wartime products which had no normal peacetime use. At Carteret and South Charleston plants were erected to produce barium nitrate, an important ingredient

of incendiary bombs, pyrotechnic flares, and other explosives. The combined daily productive capacity of these plants was larger than the entire monthly peacetime consumption. The South Charleston plant also produced hexachloroethane, for use in smoke-producing mixtures, of which there had been no previous commercial production in this country. For the synthetic rubber program, Westvaco produced a highly secret catalyst for which an award of merit was received when the synthetic rubber industry received the annual *Chemical & Metallurgical Engineering* award. Westvaco was also one of the DDT producers.

When the war ended, Westvaco, like other chemical producers, turned its attention to its interrupted development program. In Wyoming a shaft is on its way down to a large underground deposit of natural trona, which may mean that Westvaco will one day be a large producer of soda ash. A moderate-scale Insecticide Department has been built around DDT, benzene hexachloride, methyl bromide, ethylene dibromide, carbon tetrachloride, and carbon bisulfide. Plans are under way to make more new insecticides.

Westvaco Chlorine Products Corp., originating from a modest production of sodium phosphates, has progressed steadily until today it is among the first 20 chemical producers in the United States. Contemplated developments indicate continued progress which should, at the very least, maintain its present relative position in the chemical industry.

C. K. WILLIAMS & CO. existed as a partnership and a proprietorship for 23 years before it was incorporated in Pennsylvania in 1906, the year Joseph Thomson Williams, its founder, died. The directors at this time were C. K. Williams, president, treasurer, and general manager; Frank C. Williams, vice-president; James B. Neal, secretary; Hannah E. Irwin and Emma C. Ayers. With the exception of Neal, all directors were brothers and sisters.

The year 1878 saw the end of a depression and the beginning of a profitable and productive era. It was this year that Joseph Williams, recognizing the growing demand for mineral fillers in the paper, paint, and soap industries, discontinued farming in Montgomery Co., Pa., and went to Easton, where he acquired 62 acres on which several soapstone quarries were located. Five years later young Charles K. Williams, who had been trained as a machinist, joined his father. The elder Williams had leased a former flour mill, in which he was producing about one-half ton of ground soapstone per day, but this mill was soon abandoned in favor of an idle one on his own property. In 1886 D. D. Wagener & Co. at Easton discontinued, and after taking over their mill the Williams were able to produce 15 tons of talc per day, always dependent on the water supply in the Bushkill Creek, the only power available at the time. This mill is still operating on a limited scale.

Within a few years a New York talc, whiter and more fibrous than that found at Easton, entered the market. This compelled the Williams to secure other things to grind: slate, colored shale, and iron ores. Their second venture in milling operations, the manufacture of umbers, ochers, and siennas, began in 1890, with the leasing of a near-by dry color mill owned by J. S. Rodenbough & Co. At the close of the 19th century the Lehigh Valley formed an important center for the production of pig iron and by-product umbers, ochers, and siennas of acceptable quality. As the need for these earth pigments in the paint industry was considerable, the Rodenbough mill was soon outgrown. A new plant, known then as the Lucy Ochre Works, was built at Easton. It formed the nucleus of the Company's major plant today, where dry color production approximates 75% of C. K. Williams' business, with the original line greatly expanded.

There were also several deposits of iron ore and siderite in the area and the

Williams built mills in which to process them into pigments for metallic browns for freight car and barn paints. Mineral blacks were found abundantly associated with the anthracite coal deposits in Pennsylvania, and these were also utilized for the manufacture of black fillers and special pigments.

The Williams' business was almost wiped out in 1893 by two disastrous fires. The Rodenbough plant was destroyed first, luckily just when a newly built dry color plant was beginning operation. Six weeks later, however, the new plant burned to the ground. No insurance was carried at the time and most men would have been too discouraged to rebuild, but the Williams borrowed capital and built a fireproof plant. In 1902 the major portion of this plant was again destroyed by fire and again reconstructed. A third fire in 1906 was a further setback. Another rebuilding program was undertaken, and the Easton plant today stands as a monument to C. K. Williams, who in the face of discouragement and limited capital devoted his life to the development of pigments and fillers so essential to industry. The Company early imported the best quality of natural earths—clay from England, iron ores from Persia and South Africa, siennas from Italy, and umbers from Cyprus—to convert into these products.

In 1900 Williams undertook to convert into bright red pigment much in demand the waste product of pickling operations in a near-by steel mill. A new plant was built in which iron sulfate solutions were transformed into crystal copperas, which was then calcined with hydrated lime, finally to emerge as Venetian red. That year Charles P. Ayers, a brother-in-law of C. K. Williams, with experience in operating flour mills, joined the Company as general superintendent and until his death in 1933 was instrumental in the development of much of its special calcining and milling equipment.

About 1905 a new unit was constructed for the manufacture of commercially pure oxides and Indian reds from copperas, and subsequently production of synthetic black iron oxide was undertaken. Martin O. Wolbach, Sr., who was experienced in the use of pickling solutions in steel operations and who had become associated with the Company in the late 1890's, assisted in the development of these synthetic pigments. He served as plant superintendent for many years and later devoted himself to development of processes until his death in 1923.

From the modest output of one-half ton of soapstone per day, the Company's capacity has been developed and its production diversified to the extent that it now supplies a complete range of essential mineral colors and fillers for building materials, ceramics, chemicals, electrical equipment, floor coverings, glass, inks, leather, metal alloys, paper, pharmaceuticals, plastics, paint, rubber, textiles, and other products. Guiding principles of C. K. Williams and his company have been utilization to the greatest possible extent of raw materials available locally; control so far as possible of sources of raw materials; sound, conservative expansion and growth. During the past 40 years there have been acquired or established several small businesses, principally raw material plants, which have since been liquidated or merged. Today there are 12 subsidiaries, some purchased and others developed as new ventures.

In 1919 George S. Mepham & Co., at E. St. Louis, Ill., was acquired and incorporated. Owned by George Saxe Mepham and in existence in St. Louis since 1886, it produced pigments similar to those made at Easton. Acquisition of this plant enabled C. K. Williams & Co. better to supply Midwestern customers. Under Lorenz K. Ayers, president and general manager, the business has kept pace with the growth of the Middle West, and the plant has been consistently rebuilt and enlarged for the production of an increasing volume of natural and synthetic iron oxides and allied pigments. Also acquired in 1919 was the Point Milling & Manu-

facturing Co. at Mineral Point, Mo., where barytes was mined and ground. A mining subsidiary, the Midwest Mining Co., was established at Richwoods, Mo., in 1941 to supply the growing demand for barytes, and is the largest mill of its kind in the district. The Acme Barite Co. was established at Mineral Point in 1944, to purify barytes for specialized uses in the glass industry. All three plants are managed by Ayers.

Other producing units acquired by Williams are Sulphiro Co. of Martins Ferry, O.; Blue Ridge Oxide Co., Lehigh Gap, Pa.; Seminole Pigment Co., Warren O.; Synthetic Iron Color Co., Richmond, Calif.; iron ore mines at Fruitland, N. Y.; and several ore mines and a grinding plant in Spain. New companies are Calcium Chemical Corp. at Adams, Mass., and C. K. Williams & Co. of California established at Emeryville in 1927 and ably managed by Verne Frazee. This important Far Western branch produces a variety of iron oxide pigments.

James B. Neal, a boyhood friend of C. K. Williams, joined the Company about 1890 to take charge of office and sales, and continued in that capacity until his death in 1939. For many years sales were handled largely by manufacturers' representatives in the principal consuming areas, assisted by George W. Mitman, who had joined the Company in its early stages and until 1920 was its only salesman. The Company's Sales Department now consists largely of technically trained men.

A research program initiated in 1929 has been expanded consistently, and chemical, physical, and engineering laboratories are maintained. Attention is devoted to improvement of existing products and development of new ones; applications in industries which constitute the Company's markets; and study of processes and techniques involved in the manufacturing of colors. Several patents, covering a broad range of products and processes in the pigment field, have been developed.

During World War II mineral pigments were the principal ingredients of most camouflage finishes, and were important components of protective coatings, including fabric finishes, and enamels and paints for aircraft, ammunition, naval vessels, Signal Corps instruments, tanks, military vehicles and weapons, etc. The Company cooperated closely with the military in producing special, essential pigments.

Today C. K. Williams & Co. is the largest producer of mineral pigments in the United States. While the nature of the business is such as to preclude spectacular growth, progress has been consistent and on a sound basis, due largely to the ability and integrity of the management under the leadership of C. K. Williams, who continued his active interest until his death in 1944. The present directors of the Company are Morris R. Williams, son of C. K. Williams, president and treasurer; Ewart G. Davies, vice-president and secretary; Russell H. Wolbach, and Joseph W. Ayers, vice-presidents; L. K. Ayers; and Verne Frazee.

WITCO CHEMICAL COMPANY originated in May 1920 as the Wishnick-Tumpeer Chemical Co., selling agents for basic chemicals. Robert I. Wishnick was the founder of this Illinois corporation, with Julius and David Tumpeer as active participants. Later the name was shortened to Wishnick-Tumpeer, Inc. Offices were first established in Chicago with four employees, but the business soon developed rapidly and an office was opened in Cleveland, which was then becoming the center of the rubber industry. Technicians were discovering the value of chemicals in improving tire performance and Wishnick-Tumpeer started supplying these new demands. The activities of the new organization were not limited to the rubber industry, but included chemicals for the paint industry, the printing ink manufacturers, producers of paper products, ceramics, and leather. In recent

years they include the cosmetic, drug, and plastics industries. The Company's growth kept pace with the development of the chemical industry.

The business increased to such an extent that a New York office was opened in the Bush Terminal in 1924. Two years later, when Wishnick-Tumpeer acquired the New York Division of the L. H. Butcher Co., the offices were moved to 253 Front St. in N. Y. City where a warehouse was also maintained. Subsequently additional offices were established at Akron, Boston, and Detroit. In 1935 the Company had outgrown its quarters on Front St. and moved to 295 Madison Ave., where it occupies the entire 19th floor.

In 1935, while in London, Robert Wishnick formed Witco, Ltd., for the distribution of American chemicals in Great Britain and on the Continent, and for the export of chemicals to the United States. Three years later this firm merged with Harold Wilson, who had been in the color trade abroad since the start of the century, forming Harold Wilson & Witco, Ltd. In 1945 the name was changed to Witco Chemical Co., Ltd., with offices in London and Manchester. In Mar. 1944, Wishnick-Tumpeer, Inc.'s name was changed to Witco Chemical Co., in order to be more descriptive of its activities. During 1946, the business of Marshall Dill, who had been supplying chemicals to manufacturers in the West since 1900, was acquired, along with offices in San Francisco and Los Angeles.

The Company's first venture in manufacturing took place in 1924, when Wishnick acquired an interest in the Pioneer Asphalt Co. of Lawrenceville, Ill., producers of high-grade asphalts since the early part of the century, and in June 1927 purchased this company. Two additional plants for the manufacture of asphaltic products have been constructed, one in Chicago in 1938-39 and the other in Perth Amboy, N. J., in 1948. During the years new products have been developed, such as mineral rubber for tires and vibration dampeners for automobiles.

In 1928 the Company entered carbon black manufacture through the acquisition of the Century Carbon Co. This activity was expanded in 1933, when the Panhandle Carbon Co. was acquired. In 1936 Wishnick organized the Crown Carbon Co. and the Continental Carbon Co. and in 1937 had plants in operation at Sunray, Tex. In 1948 Witco Hydrocarbon Corp. started operation of a gasoline and carbon black plant at Big Lake, Tex.

During World War II, with the enforced use of synthetic rubber which requires much more carbon black in its fabrication, the War Production Board decided on additional, government-financed, channel black facilities. The Company constructed two such plants, one at Sunray, Tex., and the other at Eunice, N. Mex. The former was the first channel black project to receive approval by Defense Plant Corp., first to start construction, and first to produce carbon black in a government-financed plant. The present channel black installations at Sunray comprise the largest channel black plant in the world.

During the thirties, a new type of rubber black was made in a specially designed furnace and designated furnace black to distinguish it from the older channel black. With the new synthetic rubber, GR-S, this black proved more desirable than channel black in certain applications, and a large expansion of facilities was indicated. To supply this demand, two privately owned furnace plants were constructed at Sunray.

In 1945 the Company acquired the Franks Chemical Products Co., producers of high-quality metallic stearates since 1923. The capacity of this plant, in Brooklyn, N. Y., has since been doubled and an additional plant has been erected in Chicago to meet the needs of industry.

Throughout the life of the Company, great stress has been placed on research to develop new products; on testing and improvement of products; on service to

manufacturers in problems developing from the use of its chemical products. Originally the testing and development were done in the plant laboratories, but in 1940 a separate laboratory building was erected in conjunction with the Chicago plant. It has complete paint, rubber, and asphalt-testing equipment. In 1945 a pilot plant was added to this laboratory, which makes it possible to develop a process to the point where plant operation can be started with most of the "bugs" eliminated. At Sunray a fully equipped laboratory and pilot plant are maintained for development of new blacks and improvement of presently known carbons. A small laboratory furnace provides rapid evaluation of new procedures and practicable ones are further developed in a single-unit pilot furnace. Research on metallic stearates and the salts of other fatty acids is conducted in the laboratory of the Stearates Division of the Company at Brooklyn, N. Y. To provide complete, accurate information regarding Witco products, to investigate new applications, to develop new procedures, and to assist customers with their problems, Witco maintains a Technical Service Laboratory at 719 First Ave., N. Y. City. This laboratory, which was opened in 1946, is staffed by chemists especially experienced in rubber, paint, ink, and plastics lines.

Robert I. Wishnick has been president through the organization's existence. Julius Tumper, the original vice-president, retired from active participation in 1946, at the age of 65. In 1921 Thomas J. Starkie began his association with Witco and is a vice-president today. During World War II Starkie was chief of the Pigments & Color Section of the War Production Board. Others active in the present management are vice-presidents David Tumpeer, Joseph J. Tumpeer, and C. A. Hemingway.

WOBURN CHEMICAL group, composed of three companies, has changed the course of an entire family as also the family changed the course of this industry. Prior to 1907, the Reimolds were recognized for their skill in brewmaking. While retaining his financial interests in the Terre Haute Brewing Co. and the Worcester Brewing Corp. until shortly before Prohibition, A. G. Reimold, founder of Woburn, left his profession of brewmaster to become principal owner of a small bankrupt leather-degreasing plant in Woburn, Mass. He inquired about for a man skilled in extracting oils and grease from leather and found Edward F. O'Rourke of Boston, with whom he formed the partnership that soon brought to Woburn 95% of this business in the United States. Early recognition that the tremendous volume of waste material from its degreasing activities was of potential value, has placed Woburn in a position of leadership as manufacturers of a large variety of chemicals, including fatty acids and synthetic drying oils.

Six years after Woburn was founded, in 1913, A. G. H. Reimold, son of the founder and the present president, joined the organization upon graduation from Yale University. That same year marked the start of the Company's continuous expansion into new fields. When A. G. Reimold died in 1918, O'Rourke became president, retaining this position until his death in 1926. He was succeeded by A. G. H. Reimold, while two of his nephews, C. Phillip and Richard P. O'Rourke, joined the firm.

In 1914 a new plant was established at Kearny, N. J., and between 1918-26 degreasing plants were added at Peabody, Mass., Waukegan, Ill., and Toronto, Canada. Although leather degreasing continued as the main activity, 1926 marked the first direct attention to organized chemical research when a special department was established to develop uses for by-products. In the late 1920's Woburn began to manufacture, in Kearny, oil and grease compounds from millions of pounds of oil recovered from the degreasing process. By 1931 the demand for fatty acid

products developed by the chemical manufacturing division became so great they exceeded degreasing in business importance. Woburn still degreases approximately 85% of the country's leather, and is expanding into the degreasing of wool.

In 1932 production of fatty acids from vegetable, animal, and fish oils was begun on a large-scale basis. These acids result when the glyceride content of oils is removed by either a chemical or mechanical process. They are either sold as such or are distilled at high temperatures under vacuum to yield water-clear products of uniform quality. A fatty acid made from a particular oil consists of different component acids. Palm oil fatty acid, for example, consists of lauric, stearic, oleic, myristic, palmitic, and other acids, which may be fractionally distilled. For some purposes whole fatty acids are needed while other processes require fractionated cuts, and still others, special blends to meet peculiar needs and specifications. The original method of distillation was by means of open fire in iron or steel stills under a vacuum of about 22 inches. Another method utilized superheated steam at very high temperatures with a vacuum higher than 22 inches. Woburn, collaborating with still and electrical manufacturers, evolved stills of alloy metal heated internally by electricity and operated at vacuums of over 29 inches, which effected stabilization of purity, color, and quality previously not commercially possible.

The first volume item was a specially constructed fatty acid, called Seedine, for the manufacture of tires and other types of rubber goods, where it exerts a softening and activating effect. In conjunction with this, Woburn began manufacturing fatty acids for the preparation of alkyd resins. Originally it was asked by paint manufacturers to produce linseed, soybean, and cottonseed fatty acids for these synthetic resins. At first these products were crude, but through research, Woburn was able to develop fatty acids that were uniform in character and practically water-white in color. It also developed special fatty acids for soap and cosmetic manufacturers, introducing myristic acid, much desired for shampoos and shaving creams, in commercial quantities.

Out of Woburn's development of fatty acids for synthetic resins came its interest in synthetic drying oils. It was decided that the best possibilities lay in castor oil. The Company spent years developing dehydrated castor oil and in 1936 placed it in commercial production. Woburn's Isoline is a castor oil derivative of remarkable drying properties: greater durability and flexibility and higher color-retention. The latter makes it especially desirable for high-grade enamels used on refrigerators, automobiles, and stoves. The demand for Isoline has grown to such proportions that facilities for its production are constantly being increased. The demand for castor beans, the raw material of Isoline, was so great during the war and the supply so doubtful, that Woburn experimented in raising its own beans in Florida.

While this experiment was in progress, the Company developed a cattle feed to supply the increasing number of ranches in that state. The cattle feed producing company is now an active member of the Woburn family. It also began dehydrating other raw oils, using pressure instead of a vacuum, as in Isoline. In 1941 Conjulin and Conjusoy, or conjugated linseed and soybean oils, were perfected. These have largely replaced tung oil in the manufacture of quick-drying protective coatings and wrinkle finishes. Woburn has since developed other esters of higher alcohols which have many remarkable and special properties.

During the First World War, A. G. H. Reimold, 1st Lt., QMRC, was in charge of production of leather and leather products. With the advent of Pear Harbor, Woburn's facilities were mobilized for the production of synthetic drying oils which went into protective coatings for many Army and Navy weapons and ve-

hicles, and the Company actively participated in the synthetic rubber program. Reimold served on numerous committees and subcommittees for the Department of Agriculture and the War Production Board.

Principal executives of the three Woburn corporations are: Woburn Chemicals Corp. (N. J.) of Kearny—A. G. H. Reimold, president; R. P. O'Rourke, K. H. Reimold, and P. F. Clement, vice-presidents; R. J. Rodgers, secretary; and W. L. Atwood, assistant to the president. Woburn Degreasing Co. of Woburn—A. G. H. Reimold, president and treasurer; O'Rourke, vice-president; W. E. Casey, vice-president and secretary. Woburn Chemicals, Ltd., Toronto—A. G. H. Reimold, president; W. B. Bate, executive vice-president; G. H. C. Smith, vice-president; and W. W. Smith, secretary-treasurer.

JACQUES WOLF & COMPANY was formed Aug. 1901, when Jacques Wolf, a native of Alsace, France, formed a partnership with Richard De Ronde and began the manufacture of chemicals in Passaic, N. J., at the corner of Monroe St. and Myrtle Ave. in a building previously used for the manufacture of buggy whips, where they shared the quarters with an engraver of copper rollers for textile printing. In France, Wolf, a graduate chemical engineer from the Ecole de Chimie, Mulhouse, had been manufacturing dyestuffs, penetrants, and softeners for use in the natural textile fibers. His efforts in the United States were pointed in this direction and among the first products manufactured were alizarin yellows and Turkey red oils. At that time the well-known monopole oil, made by the patented process of Dr. Schmitz of Heerdt, Germany, was imported by the textile mills. However, importation of this oil was abandoned during the early part of World War I, and Jacques Wolf & Co. began its manufacture. Other specialties for woolen processing and for the silk-dyeing industry in Paterson were added, then materials for the cotton trade in New England.

The firm continued to grow and in 1905 was incorporated with authorized capital of $75,000, with Jacques Wolf, president; Richard De Ronde, vice-president; and Alfred Fischesser, an Alsatian previously associated with Wolf in manufacturing chemicals in Europe, treasurer. Soon after, Andrew Martin joined the firm as a salesman and later became vice-president.

A number of the products made at that time were novel in the American textile field and the firm enjoyed prosperity from the very beginning. In 1906 the present site of the Clifton, N. J., plant was purchased at the corner of Center St. and Lexington Ave. It consisted of a one-story brick building which housed the laboratory and office, while a new two-story brick structure was erected in the rear for manufacturing. Expansion was rapid and ever-increasing facilities were added until at present the plant consists of 24 substantial buildings covering five acres.

The Company gradually added such special products as Bensapol, Cream Softener, and many more which still enjoy wide application. In the early days of the silk-dyeing industry, one of the complexing problems encountered was the degumming of pure silk. For this the Wolf laboratories developed boil-off oil which solubilized the sericin faster than was possible with soap alone.

World War I brought a great shortage of chemicals, among which an important one for the discharge printing of textiles was sodium formaldehyde sulfoxylate, imported from Germany. Wolf soon met this challenge with a satisfactory product first in liquid form and then crystalline, sold as Hydrosulfite AWC, which contributed to the continued growth of the textile printing industry in the United States and its great expansion following the war. Leucotrope W for the discharging of indigo-dyed cloth was also developed and marketed under the name of Indigolite. Chrome black and sulfur black dyes, also produced in large quantities,

were discontinued after the war so that the Company might follow its production policy of more specialized chemicals.

Constant research and the necessities of the trades brought about the manufacture in 1921 of proteolytic and diastatic enzymes for the removal of starch and protein matter from textile fibers. Further study led to enzymes for the clarification of fruit juices and jellies, chillproofs for beer, and digestants for dog and poultry feeds. These were sold under the registered names of Diastazyme and Protozyme. Further exploration of enzymes for tanning led to the development of Fungizyme for dehairing and bating of hides. Study of seaweed products developed emulsifiers, stabilizers, and thickening agents for the food and drug industries. These highly refined carragheen sulfates, trade-named Gelloid, have the widest use in making chocolate milk drinks.

At about this time the silk dyeing and printing industry was enjoying expansion as the demand for pure silk was at its peak which brought new problems and the manufacture by the Company of tin tetrachloride for weighting purposes. As the full capacity of the Clifton plant was taxed, additional manufacturing facilities were acquired at Carlstadt, N. J., where tetrachloride of tin was produced in large quantities, but later discontinued when synthetic fibers became more important. At Carlstadt, with its area of about 13 acres, new products were developed and new buildings erected. Manufacture of hydrosulfite of soda was started as well as synthetic tanning materials, penetrants, and wetting agents from the newly developed processes of petroleum and naphthalene bases. To insure purity of product and efficiency of manufacture, the Company installed at Carlstadt equipment to produce its own SO_2 and zinc dust, the chief ingredients in the production of sodium hydrosulfite. Greater expansion of the syntans, marketed as Synektans and Tanasols, and installation of modern equipment followed. Lomar, a dispersing agent for highly dispersed pigments, carbon black, etc., has added greatly to the Company's sales.

During World War II an important peacetime chemical manufactured at Carlstadt found immediate application by the Armed Forces, and Jacques Wolf & Co. at that time was the only domestic producer of barium and strontium nitrate. Called upon to utilize substitutes and to obtain new sources of supply, the Company's directed research into many fields which might not otherwise have been explored, resulted in the development of many important products now being manufactured.

Through the years Jacques Wolf & Co. has not confined itself to the manufacture of chemicals, but has dealt in many imported products, particularly water-soluble gums. At Passaic, it has a large capacity for milling tragacanth, karaya, and gum arabic—imported directly from the countries of origin—which find outlets to the textile, pure food, and pharmaceutical trades. The Company established an export department about 1937 and this end of the business has become very important, with representation in practically every country.

During almost a half-century the Company has experienced continuing changes in styles, finishes, and new fibers such as rayon, acetate, aralac, and nylon, which have demanded new products to keep pace with the trade requirements; the most recent being Dileine and Meleine, compounded to overcome the gas fading of acetate dyed fabrics. These are permanent finishes and meet all the specifications of the American Association of Textile Colorists & Chemists. Wolf's line now embraces some 1,500 products, and many United States patents on them have been issued or assigned to the Company.

The Company has had the continual guidance of its founder, Jacques Wolf, who is the incumbent president, assisted by Schuyler E. Tylee, vice-president and treas-

urer, and Gerald J. Desmond, secretary and sales manager, both long with the organization. They were joined in 1930 by Arnold Pfister who is now a director and manages manufacturing operations in all plants. The firm is represented by its own salesmen in New England, Middle Atlantic, Midwest, and Southern states. In 1943 a branch plant and office were established in Los Angeles to serve the Pacific Coast.

WYANDOTTE CHEMICALS CORPORATION, known for more than 50 years as the Michigan Alkali Co., was founded by Capt. J. B. Ford, a pioneer in the glass industry, who laid down the basic principles of the Company, carried on by the Ford family throughout the organization's continued expansion. Captain Ford formed Michigan Alkali in 1890 as a source of supply of soda ash for the glass industry. There was then only one soda ash factory in the United States, at Syracuse, and this could not supply the country's growing demand for ash. Large quantities had to be imported, so Captain Ford decided to investigate the possibilities of producing soda ash.

Since salt, limestone, and coal were the three basic ingredients, it was necessary to locate a practically limitless supply of these materials close to the Allegheny Valley where glass was made. The famous salt deposits at Syracuse were preempted by Solvay and the Virginia deposits were held by a group of New Englanders later to become the Mathieson Alkali Co. Therefore Ford turned to the more recently discovered salt deposits at Wyandotte, Mich. These beds were found to contain a layer of salt 95 ft. thick, 850 ft. below the surface and a second layer 200-300 ft. thick and 1,200 ft. underground. This inexhaustible supply of salt and tremendous deposits of limestone near by made this an ideal site, since coal could be shipped in by rail easily and the Great Lakes waterways provided excellent shipping facilities by boat.

Following his old custom, Captain Ford did not incorporate at once but operated personally under the name of J. B. Ford & Co. until 1893, when the Michigan Alkali Co. was formed. The first brine well was sunk in 1891 on a 40-acre tract of land and the first frame buildings were erected where the South plant now stands. Plant #1 was built by Vinton & Co. of Detroit, at a cost of $20,000, and the equipment was valued at $80,000. This installation was an ammonia-soda process, but it was poorly designed and did not function economically. Convinced that the operation was bound to fail, Ford followed the precedent he had established in the plate-glass industry and sent to England for technically trained men. Herbert and John Watson accepted his proposals and came to America. At Wyandotte the Watsons reconditioned the plant and produced its first commercially salable soda ash, around 15 tons a day, employing 90 men. Soon after this H. A. Galt, who later had a distinguished career in alkali manufacturing with another company, became superintendent. He was joined by William T. Orr, a Scot, who later became superintendent and general manager, and an Englishman, H. R. Browne, who later directed Michigan Alkali chemistry. From this point the Company developed rapidly. Two and one-half years after its formation, it was incorporated as Michigan Alkali Co. with a capital of $1,000,000, increased to $2,500,000 in 1896. Captain Ford distributed the stock to his descendants and expansion was begun on a production that had already reached 90-100 tons per day.

Following his custom of starting another factory after the first had gotten under way, Captain Ford purchased a second tract of land at Wyandotte, just beyond the northerly limits. In 1895 the first buildings, 60 ft. x 100 ft., were constructed at the North plant with a capacity of 250 tons per day, employing 600 men. The following year 12 brine wells were drilled at the North plant and a

caustic plant with a capacity of 100 tons per week was erected at the South plant. A bicarbonate of soda plant was also completed there with a capacity of 50 tons per day. In 1897, following an eye operation, Captain Ford retired, and his son Edward, recently retired as president of Pittsburgh Plate Glass, then became president of Michigan Alkali. The following year, Captain Ford approved the creation of an affiliated enterprise to refine the parent company's products and adapt them to specialized consumer use. Accordingly, the J. B. Ford Co. was incorporated for $100,000, Apr. 29, 1898. This capitalization was increased to $2,500,000 in 1922.

In 1903 Michigan Alkali acquired limestone quarries at Alpena, Mich., and arranged to ship the stone to Wyandotte by rail. Previously all the limestone had been gotten from the quarries just outside of Wyandotte, and from Kelly Island in Lake Erie, but the Alpena quarries contain the best limestone for making alkali. Shipments by rail were continued until 1908 when it was decided to experiment with a water route. A new self-loading steamer, the *Wyandotte,* was designed by George B. Palmer, head of the Engineering Department. Thunder Bay was dredged and a timber-pocketed dock of about 3,000-ton capacity constructed. The *Wyandotte* proved very successful for handling stone, and new boats, the *Alpena,* the *Huron,* and the *Conneaut* were added. In 1914 a new steel dock was built with a capacity of 7,000 tons. The original timber dock was replaced by a concrete dock in 1922 with a capacity of 10,000 tons.

When the Alpena quarries first began production, the output was about 300 tons a day. Within four years this increased to 5,000 tons through the introduction of modern equipment. Today the output is about 10,000 tons, one of the most impressive open-pit excavations in the world. Roughly five-eighths of a mile in diameter, it occupies more than 200 acres, produces 200,000 tons of stone to the acre, and has two 45 ft. levels or a depth of 90 ft. The entire quarry is now completely electrified, power coming from the Huron Portland Cement Co. whose plant is located close by on Thunder Bay Harbor. Although Huron is a separate and independent corporation, a majority of its stock is owned by members of the Ford family. Organized in 1907 to utilize the smaller sizes of stone, or macadam, produced in the quarry, Huron Cement has developed an independent business with a large production and a fleet of specialized cement-carrying vessels. The electricity with which it supplies the quarry is generated in waste-heat boilers installed at the end of the revolving kilns used to make the cement.

In 1904, to facilitate movement of materials in and between its plant at Wyandotte by rail, Michigan Alkali organized the Wyandotte Terminal R.R. Co. with an authorized capital of $15,000, which was eventually increased to $500,000. A year later the Company's marine activities were incorporated as the Wyandotte Transportation Co. for $100,000, later increased to $1,000,000. In addition to operating its own steamships, Wyandotte Transportation also charters other vessels when necessary to handle all of the coal and limestone. To complete its marine transportation, Michigan Alkali incorporated Michigan Atlantic Corp., Jan. 28, 1935, with an authorized capital of $50,000, the beginning of an interesting experiment in water transport from the Great Lakes to the Atlantic. The Diesel-driven barge, the *Michigan,* travels a regular five-day schedule from Wyandotte to New York, covering the distance in only a day more than required for the usual freight haul and at a greatly reduced cost.

In Mar. 1909 the Ford Colleries Co. at Curtisville, Pa., was organized to supply coal to Michigan Alkali. This operation began with only $5,000 and is now incorporated for $100,000. From these mines comes the bituminous coal that produces the coke necessary to the ammonia-soda process. The output is about 6,000 tons a day. Another subsidiary of Ford Colleries, the Natural Soda Products Co.,

which was organized to produce alkali products from natural brine at Owens Lake, Calif., was acquired in 1934 to supply soda ash to West Coast customers.

During this period of expansion and formation of subsidiaries, the original alkali plants were also being expanded. The original wooden buildings were rebuilt in brick, later replaced with brick and iron, and finally became concrete and steel. The first bicarbonate plant erected at the North works in 1897, was rebuilt in 1904-5, and when this became outmoded, an entirely new plant was completed in 1926. The first coke plant built in 1902 was completely replaced in 1927. The cement plant was built in 1927 to process by-product materials that were once wasted. The new dry-ice plant, largest in the world, with a daily production of 275 tons of solid carbon dioxide, dates only from 1932. The calcium carbonate plant was built in 1939 and expanded in 1947. Practically all the processing plants have been rebuilt and enlarged since 1925, so that the North works, which originally produced only soda ash, now has extensive operations in ash, bicarbonate, calcium carbonate, coke and coke by-products, tar, toluene, benzene, xylene, and ammonia. Laboratories, foundries, machine-shops, car repair shops, cooper shops, and other general service structures have been erected. At the South works the products are even more diversified, including in addition to ash, chlorine and its by-products, bleach powder, ferrous chloride, sodium and calcium hypochlorites, caustic soda, calcium chloride, solid carbon dioxide, and cement.

Throughout these years of expanding business and improving processes, a steady pressure has been exerted to lift Michigan Alkali products to higher standards of purity. This has now reached a point where its bicarbonate of soda goes directly into medicines, while the caustic soda without any further refinements is available for various operations in the manufacture of delicate textiles. And this development is still being continued. In Jan. 1943 Michigan Alkali and the J. B. Ford Co. were consolidated, still under the same family ownership, to form the Wyandotte Chemicals Corp. In 1946 Wyandotte announced a $25,000,000 expansion program for the purpose of increasing its facilities and entering the organic chemical field with the construction of plants for the manufacture of glycols and synthetic detergents. These plants will be in production the early part of 1948.

And so what was originally intended as an aid to the glass industry has become part of a major industry itself, and more remarkable, throughout its growth the Company has remained in family ownership. Following Captain Ford's retirement, his son, Edward, succeeded him. In 1898 Edward left Wyandotte to found a large glass business, but retained the presidency of Michigan Alkali until his death in 1920, visiting Wyandotte only at intervals after 1898. He was succeeded by J. B. Ford, Sr., grandson of the Captain, who became executive head at 32. Under his direction much of the Michigan Alkali expansion took place. Upon his retirement in 1939, his cousin E. L. Ford became president until his death in 1942. His son Emory M. Ford was elected in Jan. 1943, and, assisted by other members of the family who constitute the board of directors, he is now directing the Company's latest expansion into the field of organic chemicals.

ZINSSER & COMPANY, INC., was established by Frederick G. Zinsser in 1887. Before this, he had been associated with William Zinsser & Co., which manufactured spirit varnishes, bleached shellac, and preservatives for the canning and beverage industries. The purchase of the American rights of the Kolbe patent for the synthesis of salicylic acid made this company the first to produce a synthetic organic chemical in the United States on a commercial scale. In 1896 Zinsser severed his connections with the old firm to enter the wider field of organic chemistry.

The new company started with the production of tannic acid and hematine crystals. To avoid the rehandling of the wood imported from the West Indies, it was decided to locate on a navigable river. An abandoned sugar refinery at Hastings-on-Hudson was acquired and production began as soon as buildings and equipment were ready. Hematine was successfully produced for several years until the ruinous competition of a company located in Jamaica made its manufacture unprofitable. Tannic acid is still one of the Company's products. Work with tannin naturally led to gallic and pyrogallic acids and the latter, in turn, to the production of photographic developers—hydroquinone and derivatives, *p*-aminophenol, and metol.

At the beginning of World War I, the Company was commissioned by the Army to build a small-scale mustard gas plant, which eventually developed into an installation for a daily production of 75 tons, and which was finished and in operation some time before the Armistice. The demand for gallocyanin during the war had made gallic acid a tonnage project and when the large demand for this dyestuff ended, a new outlet had to be found. Gallic acid browns (alizarin browns) used in the wool dyeing and cotton printing industries were the first produced, followed among others by alizarin blue blacks, cyanin greens, and acetate colors for the coloring of Celutate fibers, etc.

In 1926 the Company merged with the Ultro Chemical Co., manufacturers of high-grade organic pigments and toners, such as fire red, Hansa yellows, benzidine yellows, madder lakes, and many others.

During World War II the Company's facilities were requisitioned by the Army for the production of anthraquinone colors used in the manufacture of tracer shells and bullets, tannic acid for the treatment of burns, and photographic developers for the Signal Corps. The Company has now returned to peacetime developments under the guidance of F. G. Zinsser, chairman of the board; James L. Berston, president; Harold W. Dingee, vice-president and sales manager; Roscoe J. Perry, vice-president and production manager; and Herman T. Staber, secretary-treasurer.

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